SOURCE CONTROL
REMEDIAL INVESTIGATION REPORT
FOR
SHERIDAN DISPOSAL SERVICE SITE
HEMPSTEAD, TEXAS

003358

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY
TEXAS WATER COMMISSION

BY

SHERIDAN SITE COMMITTEE

JULY 1987

RESOURCE ENGINEERING

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SHERIDAN DISPOSAL SERVICES SITE

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EXECUTIVE SUMMARY

The purpose of this Remedial Investigation Report is to characterize the Sheridan Disposal Services (SDS) site and to summarize the data collected and conclusions drawn from the remedial investigation of the SDS site. The purpose of the remedial investigation was to determine the nature and extent of any environmental threat from the SDS site and to gather the data necessary to develop a study of feasible alternatives for remedying any such threat. 003377

SDS, owned by Mr. Duane Sheridan and in operation from the late 1950s to 1984, was a permitted commercial solid waste disposal site. It is located on a 700 acre tract owned by Mr. Sheridan in Waller County, about nine miles northwest of Hempstead, Texas. The surrounding area is primarily farm and grazing land.

The principal waste operations involved storage of various waste materials in a pond of between 12 and 22 acres, depending on water level, and waste incineration. At its closest point, the pond is about 200 feet from the southern bank of the Brazos River. A 42-acre evaporation system was added in the 1970s to handle excess stormwater.

SDS received its first waste disposal permit from the State of Texas in 1963, and continued operations until early 1984 when the Texas Department of Water Resources ("TDWR") ordered the site closed. In January of 1984, the TDWR contacted certain companies whose waste may have been disposed at the site requesting that such companies conduct an evaluation of present conditions and assist SDS in future management of the inactive site.

The companies contacted by the TDWR formed the Sheridan Site Committee which, through its contractor, Resource Engineering, Inc. (REI) has conducted extensive site surveys and interim remedial actions during the ensuing two years. This Source Control Remedial Investigation Report presents the results of the investigation performed on behalf of the Sheridan Site Committee and under the direction of the TDWR and/or the U.S. EPA. Additional groundwater studies are currently ongoing and will be reported in the Groundwater Migration Management RI report (GWMM). Set forth below is a summary of the major findings of this Remedial Investigation Report.

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Findings Regarding Any Environmental Impact

1. Continuing response actions have and will be implemented so that the site may not pose an immediate threat to human health or safety or the environment through air emissions, direct contact or surface water runoff. The potential risks presented by the site will be further evaluated in the Endangerment Assessment. Response actions completed

include: removing oil from the pond surface, evaporating about nineteen million gallons of excess stormwater from the pond, improving and elevating the dikes surrounding the pond and the evaporative system and installing a fence around the pond and evaporative system.

2. The site is in a rural area of Waller County. The nearest resident is the site caretaker located in a mobile home 2,000 ft. southeast of the pond.

3. The site's remote location coupled with the fence surrounding the site restricts access to the site by animals or people.

4. A water table aquifer located approximately 55 feet below grade at the site, naturally discharges slowly into the Brazos River. The impact of this discharge is so minimal that water samples taken from the Brazos River immediately upstream and downstream of the site show no measurable impact on the river by the site.

5. The first usable aquifer (capable of sustaining more than 2 gpm) at the site is located approximately 80 feet below grade. This aquifer will be referred to as the first confined aquifer. Boring logs show that this aquifer is separated from the upper water-bearing zone by a 25 to 40 foot thick clay stratum.

6. There are no wells withdrawing water from the upper water-bearing zone downgradient of the site.

7. Dikes around the pond extend one and a half to three feet above the 100-year floodplain elevation to prevent waste from washing into the river during floods.

8. Riverbank erosion on the Brazos poses no immediate threat to the site. Left unchecked, at current erosion rates the river could intrude on the waste materials in approximately 100 years. At that time, significant contamination of the river could occur.

9. Recorded values of air contaminants from the SDS site are at detection limits and well below acceptable exposure concentrations. The closest potential receptor is the site caretaker located approximatley 2,000 feet southeast of the pond in a mobile home. However, the nearest permanent resident is located one mile away. Recorded values of air contaminants at the bank of the pond are at normal rural background levels which are substantially below typical values occurring in urban areas.

Findings Regarding Waste Materials Requiring Management

1. Assuming an average sludge depth of three feet, approximately 100,000 cubic yards of organic and inorganic sludges lie at the bottom of the 22-acre pond and under the surrounding levee. These sludges contain metals, chlorinated and non-chlorinated organics, phenolics, polyaromatic hydrocarbons, inorganic salts and polychlorinated biphenyls.

2. Assuming three feet of contaminant migration into subsoils, it is estimated that up to 60,000 cubic yards of contaminated subsoils are found beneath the pond sludge. It is possible that once remedial action is undertaken the extent of contaminated subsoil under the pond sludge could be found to be greater or less than the assumed three feet.

3. There are approximately 8,000,000 gallons of stormwater within the pond. Analyses have shown low levels of organic contamination. Over the years, such stormwater has been evaporated in the evaporative system.

4. A floating oil layer now covers about 15% of the pond surface.

5. The levee system surrounding the pond was originally constructed with local site soils (predominantly clays and clayey soils), sludge, and ash residue from the incineration process. The levee system volume is estimated at 220,000 cubic yards, and approximately 20% of this volume is from processed waste materials.

1.0 INTRODUCTION

1.1 Site Background Information

1.1.1 Site Location and Description - The Sheridan Disposal Service (SDS) site is located approximately 9 miles north-northwest of the City of Hempstead in Waller County, Texas. It is two miles northwest of the intersection of Clarke Bottom Road and Farm Road 1736 at 96°80'00" east latitude and 30°12'30" north longitude. The waste management areas occupy an area of approximately 110 acres out of a 696.5-acre tract of land bordered on the north by the Brazos River and on the south by Clarke Bottom Road. Figures 1-1 through 1-3 illustrate the site location.

The Sheridan Disposal Service (SDS) site began operating as an industrial waste disposal facility in the late 1950s. At present, the site includes a 42-acre land irrigation/evaporation system, and a pond which has ranged in size from 12 to 22 acres depending on water levels and partial closure actions undertaken by SDS. The levee/dike around the pond has a surface area of approximately 17 acres, including portions of the pond which have previously been covered. An incinerator and a battery of 9 storage tanks which were used for separation and treatment of oil/water emulsions and storage of solvents and fuel oils are located on the pond levee.

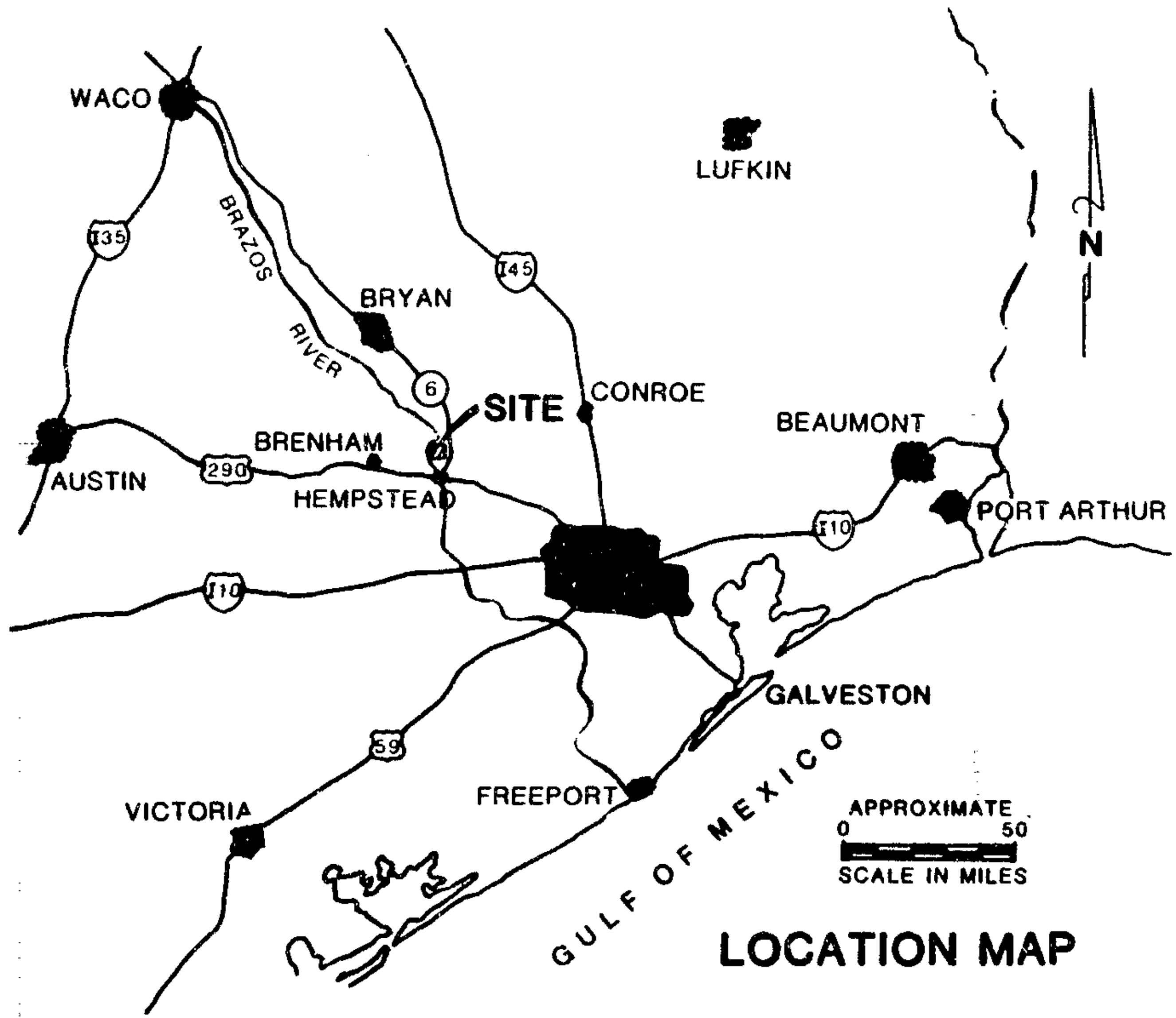

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FIGURE 1-1
SHERIDAN SITE LOCATION
SHERIDAN DISPOSAL SERVICES

DRAWN BY:
DATE:
PROJECT NO. 288-04

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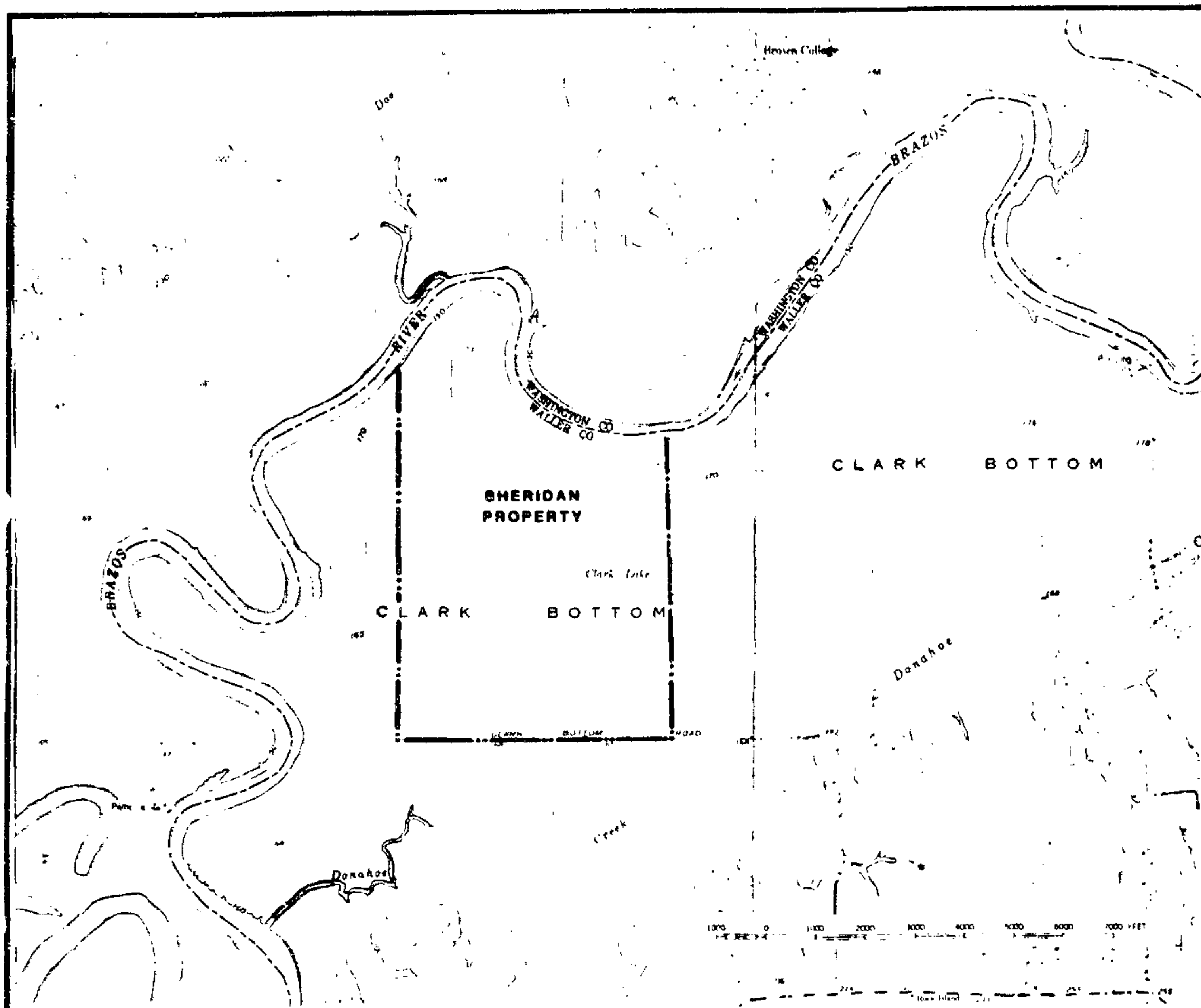

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FIGURE 1-2
SITE LOCATION MAP
SHERIDAN DISPOSAL SERVICES

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Aerial View of Sheridan Site Looking West

Aerial View of Sheridan Site Looking Southeast

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FIGURE 1-3
AERIAL VIEWS
JULY 1985
SHERIDAN DISPOSAL SERVICE SITE

DRAWN BY:	DATE:	PROJECT NO.
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1.1.2 Site Operating History - In the late 1950s, Mr. Duane Sheridan began treating and disposing of industrial wastes on a 15-acre portion of his farm/pasture in a natural low-lying area which became the pond impoundment. Sheridan Disposal Service's operating practices included open pit burning of combustible wastes for volume reduction. To handle additional waste, the size of the pond was gradually increased to a maximum of 22 acres.

From the beginning of operations through 1971, open burning and impoundment of wastes were the operating practices. In September of 1971, construction began on a battery of storage and treatment tanks in response to an order from the Texas Water Quality Board (TWQB). Additionally, a system of ground flares was installed in 1972.

From mid-1971 through 1974, operating practices consisted of steam treating oil-water emulsions in the receiving tanks and using separated petroleum oils as fuel for the ground flares. During this period, a 400,000-gallon receiving pond located on the northwest section of the pond impoundment levee was used for unloading and initial storage of wastes. From there, wastes were pumped to the steam treatment tanks for emulsion breaking. Recovered waste oils were sold or used as fuel for the boiler and ground flares and, later, the incineration system. Residue or ash from open burning and flaring was disposed of in the impoundment. Wastes were also directly discharged into the impoundment during upset conditions or when the emulsion treatment system was overloaded.

During 1974 and 1975, Sheridan Disposal Service conducted numerous trial burns of various incineration systems. In May of 1975, SDS received an operating permit from the Texas Air Control Board (TACB) for a liquid waste burner (incinerator) designed and constructed by Mr. Sheridan.

In 1976, a land irrigation/evaporation system was constructed by Sheridan Disposal Service under the supervision of TWQB personnel for on-site management of aqueous wastes and stormwater which accumulated in the pond. Between 1976 and 1984, the system was used to treat more than 40 million gallons of wastewater from the impoundment pond, as reported to the TWQB.

At that time the major treatment operations involved surface impoundment disposal, open pit burning, incineration of combustible wastes, land evaporation, and incinerator evaporation of impoundment wastewaters.

1.1.3 <u>Site Regulatory History</u> - The regulatory history of the site was administered principally by the Texas Air Control Board (TACB), and the Texas Water Pollution Control Board (TWPCB), predecessor of the Texas Water Commission (TWC). Sheridan Disposal Services received a waste disposal permit from the TWPCB in March of 1963. A special provision of the original permit required that any new waste streams for disposal at the site be reviewed and approved by the TWPCB staff. Agency records indicate that Sheridan Disposal Service was reasonably diligent in obtaining agency approval before accepting new waste streams.

Regulatory inspections of the facility began as early as 1963 in response to complaints from local area residents of odors and surface water runoff. In July of 1970, the Texas Water Quality Board (TWQB), successor to the TWPCB, and Waller County, filed suit against Sheridan Disposal Services for surface water discharges in violation of its waste disposal permit. After a series of TWQB meetings and public hearings, the suit was settled in March of 1975. The TWQB directed Sheridan Disposal Service to provide additional capacity for waste disposal through new treatment processes. During the implementation of these plans the TWQB allowed delays for Sheridan Disposal Service to acquire sufficient capital for expansion and to begin closure actions for the existing impoundment. In 1979 the TWQB ordered the pond closed. Pursuant to that order, only combustible waste for incineration was permitted to be accepted at the site.

An initial closure plan was developed by the TWQB and SDS which required:

- The transfer of stormwater accumulated in the pond to the evaporation system for treatment.

- The capping of the pond using construction debris (i.e., soil, dirt, rocks, sand, tree branches, roots and stumps). Capping was limited to those areas of the pond bottom exposed by removal of lagoon stormwater.

- The pond levee not be disturbed during the initial phase of closure.

- The maintenance of a two-foot minimum separation between the top of the fill material and the pond levee crest elevation during initial closure activities.

At this time, Sheridan began site closure by transferring pond water to the evaporation system for on-site disposal, backfilling the waste recovery pond and initiating pond capping, beginning at the southwest side. Approximately seven acres of the pond area were closed in this manner, with additional capping closure activities awaiting receipt of suitable fill materials.

By 1984, the Texas Department of Water Resources (TDWR), successor to the TWQB, had concluded that Sheridan Disposal Service lacked the technical and financial resources to adequately close the site. The TDWR's primary closure concerns were the potential for local groundwater contamination and the possibility of eventual encroachment of the Brazos River onto the site. These concerns prompted the TDWR to notify generators and transporters of waste materials managed at the site of their potential responsibility for closure. The agency offered these parties an opportunity to voluntarily assume this responsibility as an alternative to ranking the site under the National Priorities List (NPL) for Superfund action under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

In response to this notification, the Sheridan Site Committee, composed of more than 50 of the affected industrial waste generators and transporters, was formed. The Sheridan Committee coordinated the efforts of the group in responding to the TDWR. Shortly thereafter, Resource Engineering, Inc. was retained to provide technical assistance in developing this response.

Since February of 1984, the Sheridan Site Committee has submitted a series of site assessment reports to the TDWR for consideration as the basis for facility closure. The discovery of polychlorinated biphenyls (PCBs) in the pond at concentrations greater than 50 ppm brought the Environmental Protection Agency (EPA) into the project through their jurisdiction under the Toxic Substance Control Act of 1976 (TSCA). In March of 1985, a combination facility closure plan and TSCA chemical waste landfill permit application were submitted to the TDWR and EPA Region VI. Subsequent to this application, the EPA decided that the site should undergo closure under CERCLA. The Sheridan Steering Committee has responded by developing this Source Control Remedial Investigation (RI) report as a summary of all site investigations conducted in accordance with 40 CFR, Part 300. The SDS site was formally proposed for the National Priorities List (NPL) on June 10, 1986.

The Sheridan Disposal Service site has a background of more than two decades of operational history, regulatory actions and significant events. An overall site plot plan showing the various on-site facilities is presented in Figure 1-4. Table 1-1 provides a detailed site timeline history of these major events relative to site operations.

Table 1-1

SHERIDAN DISPOSAL SERVICES SITE TIMELINE

~1959	Duane Sheridan begins receiving industrial waste. It is disposed of within an approximately 15-acre dumping area which includes a natural low-lying area of his farm.
9/19/62	Mr. Sheridan submits an application for a waste disposal permit to the Texas Water Pollution Control Board (TWPCB). The disposal methods for industrial wastes are identified as open pit burning and surface impoundment containment of ash residue.
1/30/63	TWPCB receives letter from C.W. Karisch, Waller County Attorney, expressing the concerns of the County Health Officer due to complaints from local residents about Mr. Sheridan's disposal operations.
3/5/63	Sheridan Disposal Services (SDS) receives warning from the County Attorney for violations of Article 695 of the Penal Code. The letter was prompted by area residents complaining of "noxious odors and fumes" from wastes being disposed of on Mr. Sheridan's property.
3/11/63	TWPCB issues Waste Control Order #00508. The permit specifically authorizes disposal of two waste streams: a diatomaceous filter cake waste, and a mixed caustic liquid stream containing salts, alcohols, aldehydes, esters, ketones, and glycols at varying concentrations. Special provisions require that any other wastes disposed at the site must first be approved by the TWPCB. In addition, the special provisions require that a surveillance program, including monitoring wells for tracking ground water quality, be established.
5/2/63	TWPCB amends WCO #00508 to include two additional waste streams--one containing benzene and a mixture of ethers and a liquid waste from an insecticide manufacturing plant.

6/1/63	Monitoring well #5 and #5a are installed in the shallow water table aquifer which is the first water producing stratum beneath the site. Both wells are completed with 4" steel casing.
9/16/63	SDS notifies TWPCB that combustion residues from filter cake waste are being used to construct a levee around the pit area. Filter cake was identified as diatomaceous earth wetted with a neutral petroleum oil received in amounts of 750 to 900 tons per month.
1/4/66	The Texas Water Development Board notifies SDS of possible groundwater organic pollutants in the shallow aquifer based on analytical results of samples taken during 12/27/65 inspection.
2/11/66	The Texas Parks and Wildlife Department inspects SDS due to several complaints of dead animals reportedly caused by combustion fumes from the site. No evidence was found to substantiate the complaints.
11/15/66	The Texas Department of Health (TDH) writes SDS concerning the receipt of cyanide wastes and possible methods of treatment.
3/14/68	The TDH notifies SDS that it has no objections to the use of "pitch-like" waste material consisting of 60% to 70% pitch, 1% to 2% caustic soda and 30% to 40% phenol for stabilizing the tanks of the levee around the pit area and for road surfacing.
2/24/69	The Texas Parks and Wildlife Department inspects the site in response to a complaint and confirms an oil spill possibly due to overflow of the impoundment caused by heavy rains.
7/23/69	Texas Water Quality Board (TWQB) advises SDS that landfarming would be the best method for disposal of 6,000 barrels of oily sludge from French Ltd. of Houston, Incorporated. SDS had not yet contracted to dispose of this waste.

12/5/69	Mrs. Rosie Sheridan representing Sheridan Disposal Services testifies at a public hearing held by the TWQB concerning ground and surface water quality at commercial-industrial waste disposal pit facilities.
01/70	The TWQB receives a series of complaints on SDS operations, specifically from Mr. John C. Nelson and Mr. A. A. Reichardt.
2/10/70	The TWQB conducts an on-site inspection of the SDS facilities in response to complaints of odors and illegal "discharges" from the surface impoundment. SDS advises the TWQB representative that the most recent analysis of shallow groundwater indicates contamination. Facility is found to be in compliance with TWQB rules and regulations.
2/18/70	The TWQB conducts a follow up inspection of SDS which includes sampling of monitoring wells and surface water runoff waters.
6/5/70	SDS notifies TWQB of a spill due to heavy rains on June 2 and 3.
6/10/70	TWQB receives request from Waller County Judge, Jack Taylor, to hold a "show cause hearing in Hempstead on the existing deficiencies of the 'Sheridan Disposal Service Dump Pit'". The County Judge, County Attorney, and County Commissioner document recent spills of sludge and/or chemicals as well as receiving odor complaints from residents as far as seven miles from the site.
7/2/70	The TWQB and Waller County file suit against SDS for permit violations.
9/21/70	An inspection by the TWQB indicates that the impoundment dike has been breached by heavy rains caused by tropical storm Felicia.
12/3/70	A public hearing in Hempstead, Texas is held by the TWQB in order to gather information on waste disposal management at SDS.

12/11/70 The Hempstead Chamber of Commerce issues a resolution opposing the disposal of wastes from outside the county in Waller County.

1/22/71 The TWQB hearing examiner recommends issuance of a Board Order based upon evidence presented at the 12/3/70 public hearing. The Board is advised to consider the following recommendations:

1. Although the present permit was inadequate for protection of the environment, SDS should be allowed to remain open for 6 months in order to adopt recommendations;
2. All required improvements must be designed by a Registered Professional Engineer and be approved by the TWQB staff prior to construction;
3. A levee should be constructed around the retention pond to a level of 178 feet M.S.L.
4. Surface runoff from waste unloading areas should be collected and transferred to the impoundment;
5. A concrete monument should be installed and records kept to determine the rate of cut bank erosion by the Brazos River;
6. Drums should be returned to point of origin or crushed and disposed of in an area separate from the retention pond;
7. The company's engineering consultant should prepare a report on methods of impoundment wastewater treatment.
8. "Hazardous" waste cannot be disposed of at the site, SDS and their clients should make the determination as to which wastes are hazardous or incompatible rather than the TWQB staff;
9. At least two additional monitoring wells should be installed around the site. SDS should be responsible for quarterly sampling, analysis and reports of groundwater quality. Contaminated groundwater should be removed by recovery wells and treated before it migrates beyond the company's property;
10. At least two feet of freeboard should be maintained in the retention pond at all times; and
11. The facility should be closed if recommendations are not completed within 6 months.

3/12/71 Waller County submits comments on the TWQB hearing examiner report; Waller County favors revocation of SDS waste disposal permit. If a limited operation is allowed, the following areas should be addressed:

1. The permit should include limits on the size of the facility;
2. Only chemicals known to be safe should be disposed of in the impoundment;
3. A closure plan with financial guarantees should be part of the permit;
4. The impoundment should be lined; and
5. Waterfowl should be protected.

2/25/71 SDS writes a letter to TWQB objecting to hearing commissioner report.

2/26/71 The TWQB notifies SDS of non-compliance with the water discharge self-reporting requirements which were implemented 6/1/70.

3/26/71 The TWQB issues Order #71-0326-14.

The order allows SDS to continue operating for a three month period on a restricted basis. The order requires:

1. SDS to contract the services of professional consultants to develop an engineering plan for site improvements involving treatment and reclamation of wastes and minimizing releases to surface waters, groundwaters and the atmosphere;
2. If SDS is to close before June 25, 1971, then a closure plan must be submitted to the Board describing "how the impoundment will be closed to prevent residual adverse effects on the environmental"; and
3. At the end of a three month period, the Board will decide either to revoke the permit or allow more time for facility improvements.

7/15/71 TWQB allows SDS to remain in operation to complete site improvements and engineering studies.

7/71	O'Malley & Clay, Inc., consulting engineers, submits facility improvement plans.
9/71	Construction at SDS begins on a battery of storage and treatment tanks.
10/19/71	A meeting is held between the TWQB, Waller County and SDS 1. SDS is informed that the provisions of Board Order 71-0326-14 are not being met. 2. All wastes must be treated, recovered or destroyed in the receiving tanks. 3. Only water residues free of oil and odor will be disposed of in the lagoon. 4. No solid wastes are to be disposed of in the pond.
10/12/71	TWQB conducts weekly inspections of SDS for odor evaluations; inspections include State Parks and Wildlife Department personnel.
10/22/71	SDS informs the TWQB that sulfuric acid wastes will no longer be accepted due to odors generated upon disposal.
12/1/71	The Committee for a Clean Waller County submits a petition to the TWQB calling for the closure of SDS. The petition contains more than 500 signatures.
12/6/71	A tank truck overturns and spills its contents on route to SDS. Waller County receives assistance from the Harris County Health Department in sampling and analyzing residues from the spill.
12/15/71	The Navasota Soil and Water Conservation District informs TWQB that it is opposed to the SDS operation and questions the TWQB's permitting authority.

12/16/71	TWQB meeting - the Executive Director states that there is no evidence of ground water pollution and that the TWQB has no basis for shutting down SDS. The odor issue will be referred to the Texas Air Control Board (TACB).
1/7/72	Three additional monitoring wells (MW#4, #7 and #8) are installed.
5/17/72	O'Malley and Clay, Inc. submits report on "Compilation of Groundwater Quality Data"; MW#4 is apparently contaminated.
5/18/72	TWQB inspector notes Brazos River south bank erosion of 5-3/8" since February of 1972.
6/26/72	The TWQB completes an aquatic survey of the Brazos River and concludes that "the invertebrate fauna of the river are not suffering from any noticeable impact of the contents in the pit."
8/7/72	A TWQB report on ground water quality notes MW#4 shows significantly higher than background levels of COD, TOC, BOD_5, chlorides and sulfate. No hydrocarbons are detected by I.R. spectroscopy analysis.
8/24/72	A meeting was held in the State Attorney General's office to discuss the status of SDS compliance; present were representatives of SDS, TWQB, Texas Air Control Board, Washington County, Waller County and the Texas Railroad Commission.
9/18/72	The TACB inspects SDS facilities in response to odor complaints and notes vacuum truck discharging oily waste directly into large pond in the absence of any SDS personnel.
11/13/72	Tornado damages SDS facilities.

11/20/72 Fire destroys oil burner (incinerator) system and ignites surface of 14-acre disposal pit burning off surface oil layer.

11/29/72 TWQB Board amends WCO #00508 to the following:

1. The total volume of waste is to be limited to the treatment capacity for separation and incineration;
2. The pond will be reduced by three acres by December 1, 1973;
3. A chemist must be hired to analyze incoming wastes and a report submitted on the chemical composition of the water and sludge in the impoundment;
4. Equipment installation must be complete by August 1, 1973;
5. No materials are to be added to the pond after April 1, 1973;
6. The levee elevation is limited to 178 feet M.S.L. to prevent further disposal in the pit; and
7. A schedule is imposed for dewatering the pit based on site rainfall with closure as the final objective.

2/5/73 State Attorney General's Office requests aid from TWQB in developing a suit against S.D.S. for violations of air standards. TWQB is to provide information on any current water violations.

3/8/73 TWQB inspection finds seepage on north and west sides of impoundment levee. SDS requests extension of construction deadlines due to inclement weather.

3/9/73 TACB inspects SDS facility.

3/13/73 TACB notifies SDS that the oil burners ("incinerators") were constructed without a permit in violation of Regulation II of the TACB.

3/15/73 STS submits a permit application to the TACB for a preheater system and three "ground flares."

3/15/73 STS notifies TWQB that O'Malley & Clay are no longer being employed as consultants. STS has ceased accepting wastes until a TACB permit is received for an "afterburner" device.

3/28/73 TACB denies STS extension request. If any more materials are added to the 14-acre pond, the executive director is authorized to request legal action from the State Attorney General.

4/16/73 STS notifies TWQB that heavy rains have caused the disposal pit to fill, with less than 6 inches of freeboard remaining.

6/11/73 STS submits permit application to TACB on a proposed "excavated furnace incinerator." The waste stream is identified as mixtures of toluene, xylene, acetone, methyl isobutyl ketone, methyl ethyl ketone(MEK) and various alcohols in a water solution.

6/13/73 STS reports to the TWQB that heavy rains had caused the freeboard to again be reduced to less than 6 inches.

8/73 STS receives a construction permit from the TACB for construction of an open pit incinerator. STS notifies the TACB that the incinerator will not be built due to the company's lack of capital.

2/74 STS conducts trials on an oil burner from National Oil Burners of Pennsylvania. The trial burns fail because of excessive smoke generated in violation of TACB opacity limits.

8/74 TACB and TWQB observe a trial burn of a modified boiler/evaporator designed by Mr. Sheridan. TACB observer recommends not issuing an operating permit.

8/30/74	The State Attorney General offers new settlement to SDS which is to comply with all injunction orders and a $2,000 civil fine.
1/28/75	TWQB Executive Director reports to the Board that SDS is in noncompliance because the TACB has not granted an operating permit for a boiler/evaporator system for treatment of the disposal pit waters.
2/25/75	TWQB issues emergency order allowing SDS to raise the impoundment dike system above the 178 feet M.S.L. prior permit limitation.
3/10/75	TACB observes another "incinerator" system trial burn and notes no opacity violations.
3/15/75	Litigation originally filed 7/2/70 is settled with a Final Judgment which affirms TWQB orders and imposes a $500 fine payable to TWQB and Waller County.
3/19/75	TWQB memo states that area precipitation and evaporation rates do not correlate with rise in SDS pond levels.
3/21/75	TWQB bench tests indicate impoundment wastewater is biodegradable. Aerated lagoon treatment system capital cost estimated at $300,000.
3/27/75	TWQB District Office conducts 24 hr surveillance of S.D.S. to determine if illegal dumping is occuring.
5/9/75	TACB issues SDS operating permit #R-2172 for a liquid waste burner. Special provisions require: 1. Opacity of emissions cannot exceed 20%; 2. Dust and odor must not cause nuisance;

3. Compounds which are prohibited from incineration include:

   a) Halogens,

   b) Mixtures containing greater than 1% wt. sulfur,

   c) Chromium, mercury, lead in mixtures,

   d) Cyanides or phenols,

   e) Mixtures with inorganic solids > 0.5% by weight;

4. Open pit storage of liquid waste is prohibited;

5. Operator must be on duty and must be a certified visible emissions evaluator within 6 months;

6. A log book must be maintained;

7. All liquid wastes must be filtered prior to tank storage and incineration.

7/23/75 A TACB inspector notes opacity and odor violations at SDS facilities and recommends that the operating permit be "revoked due to repeated violations and apparent disregard of the special provisions."

9/17/75 TWQB agrees to "supervise and oversee" a land irrigation pilot project for disposal of impoundment wastewater.

10/20/75 SDS obtains a Temporary Restraining Order against the TWQB preventing a public hearing in Hempstead on permit amendments implementing a schedule for impoundment wastewater removal and treatment.

10/23/75 TWQB initiates enforcement actions against SDS for permit violations.

10/20–
12/10/75 SDS conducts land irrigation/evaporation system pilot study under TWQB direction.

1/5/76 STS consents to TWQB permit amendments.

2/6/76 TWQB issues amendments to WCO #00508 enforcing:

- a. Schedule for elimination of the impoundment and receiving pond;
- b. Requirements of site rainfall monitoring;
- c. Requirements for levee improvements.

2/10/76 STS submits a closure plan to TWQB describing land irrigation/evaporation system for impoundment wastewater treatment and proposal for covering the residual sludges with 24" of native soil fill.

3/5/76 TWQB approves land irrigation treatment of wastewater but closure plan for impoundment sludges is unacceptable.

3/26/76 TWQB changes permit identification from WCO #00508 to SW #39007 under nearly enacted Texas Solid Waste Disposal Act.

5/10/76 TWQB obtains background soil leachate data for the landfarm area.

5/17/76 STS begins operation of "46 acre evaporation/flood irrigation system". TWQB determines successful biodegradation occurs but high salt content might adversely affect future use for grain crops.

10/8/76 STS submits revised pond closure plan.

10/11/76 Toxic Substances Control Act (TSCA) is enacted.

10/21/76 Resource Conservation and Recovery Act (RCRA) is enacted.

11/76	Cumulative volume of approximately 14 million gallons of impoundment wastewater treated by evaporation/irrigation system.
2/8/77	TWQB transmits modified impoundment closure plan to SDS; Class I wastes are not allowed for fill materials.
5/23/77	SDS submits objections to modified impoundment closure plan to TDWR.
6/2/77	TACB inspector observes fire in SDS evaporation/irrigation system.
6/26/77	TWQB notifies SDS of permit deficiencies.
11/3/77	SDS covers receiving pond as requested by TACB due to odor complaints.
3/78	A spill from SDS evaporation system causes Clark Lake and Donahoe Creek to become anaerobic resulting in a fish kill.
4/18/78	TWQB enforcement inspector recommends cancelling SDS operating permit.
6/7/78	SDS reports illegal dumping by vacuum truck into a roadside ditch.
6/14/78	A fire at SDS facilities destroys a tank farm, two tractors and a butane tank.
7/27/78	TWQB estimates 17 million gallons of water treated in evaporation/irrigation system since June 1976.
10/17/78	SDS begins to fill impoundment with levee material.
3/20/79	Texas Department of Water Resources (TDWR) inspector finds dead calf in open portion of receiving pond. Incineration system not operational since major fire.

4/27/79	TWR inspection of SDS facilities indicates Clark Lake is still limited in aquatic diversity and has dissolved oxygen levels averaging <2 ppm.
6/7/79	Brazos River overflows its banks for first time since 1957 due to 11" rains. Clark Lake "flushed" into Donahoe Creek and then into Brazos River.
9/12/79	TWR informs SDS of manifest reporting requirements which are not being followed.
11/28/79	TWR authorizes use of construction debris and inert materials to begin initial impoundment closure.
12/11/80	Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) is enacted.
5/14/81	TWR authorizes a broad range of materials for use in impoundment closure excluding Class I and degradable materials.
7/6/81	TWR notifies SDS of RCRA violations.
7/24/81	SDS receives verbal approval from the TWR for disposal of drilling muds.
7/20/82	SDS notifies TWR that they no longer accept Class I hazardous waste.
9/12/82	TWR requests SDS to provide a facility closure plan and to provide a surety bond or financial assurance within 90 days.
7/12-7/20/83	EPA Field Investigation Team (FIT) surveys Brazos River, groundwater, air, pond wastes, and evaporation/irrigation system SDS. Three monitoring wells are installed.

11/3/83	TWR instructs SDS to cease all closure actions until a closure plan is approved.
11/9/83	TWR letter to SDS citing permit violations due to absence of monthly reports and no acceptable closure plan.
12/2/83	SDS submits proposed closure plan.
1/4/84	TWR rejects closure plan and informs SDS that a CERCLA site ranking package will be submitted to EPA if closure plan is not accepted by end of February, 1984.
1/4/84	TWR contacts potentially responsible parties (PRPs) requesting financial and engineering assistance for closure at SDS.
2/84	TWR revokes SDS waste disposal permit.
2/84	Sheridan Site Committee formed.
2/84	Resource Engineering Inc. is retained as engineering contractor by PRPs.
5/84	"Preliminary Site Assessment Report" prepared by Resource Engineering for the Sheridan Site Committee. Polychlorinated biphenyls are detected in the 50-250 ppm range in the impoundment sludges. A permeable spur jetty system is suggested for erosion control of the Brazos River bank. Groundwater monitoring wells #7, 10 and 12 are installed.
5/16/84	TWR requests additional site assessment data from the Sheridan Site Committee.
7/84	Sheridan Site Committee submits "Additional Site Assessment Data" to TWR. Five additional groundwater monitoring wells (#13, 14, 15, 16, and 17) are installed.

10/84 The TDWR and Resource Engineering, Inc. conduct an additional sampling survey of the lagoon sludges in order to verify PCB levels. PCB levels range from <1-221 ppm by weight.

10/29/84 The Department of the Army, Corps of Engineers, grants Mr. Duane Sheridan a construction permit for a permeable spur jetty erosion control system for the Brazos River. The permit will expire on December 31, 1987.

11/84 "Aquatic Survey of Clark Lake at Sheridan Disposal Service" submitted to the TDWR by Resource Engineering.

3/85 A "Sheridan Disposal Service, Waste Management Facility closure plan and TSCA Chemical Waste Landfill Permit Application" submitted to the EPA Region VI by the Sheridan Site Committee.

4/85 "Sheridan Disposal Service HRS Site Ranking" submitted to the EPA and TDWR by the Sheridan Site Committee.

7/15/85 EPA requests additional data from the Sheridan Site Committee necessary for completion of a remedial investigation study, requests include:

1. Installation of two pump test wells and piezometers for determining potential communication between the upper two aquifers at the site.
2. Additional GC/MS, O&G and heavy metal sampling of the evaporation system soils to a depth of at least 3 feet.
3. Sediment sampling of three locations in Clark Lake and GC/MS analysis.
4. 3 additional soil borings in Clark Lake and in situ permeability tests of the upper clay layer.

8/85 "Quality Assurance Project Plan for Sheridan Disposal Service Site Field Activities" submitted to the EPA by Sheridan Site Committee.

8/85	"Hydrogeologic Investigation Plan for Sheridan Disposal Service Field Activities" submitted to the EPA by Sheridan Site Committee.
9/85	"Sampling and Analysis Plan for Sheridan Disposal Services Site Field Activities" submitted to the EPA by Sheridan Site Committee.
9/85	EPA approves Quality Assurance project plan with revisions.
11/85	EPA approves Hydrogeologic Investigation Plan approved with revisions.
11/85	EPA approves Sampling and Analysis Plan with revisions.
12/85-1/86	Resource Engineering implements hydrogeologic investigation plan and sampling and analysis plan. Monitoring Wells 20-29 installed. Three additional borings in evaporation system area completed. Samples obtained of Clark Lake sediments, evaporation system soil samples, and test plot area soil samples.
1/86	A representative cross-section of Sheridan cattle herd is sampled to determine blood lead levels and fat tissue PCB levels.
3/86	EPA Emergency Response Team and Resource Engineering sample site ambient air for airborne organics. EPA personnel state data is to be used in Mitre HRS Evaluation of Site for inclusion on the National Priorities List. The data was subsequently not utilized in the site HRS evaluation.

1.1.4 Site Ownership - The site is currently owned by Mr. Duane Sheridan of Clarke Bottom Road, Waller County, Texas. A legal description of the area cited by the Texas Department of Water Resources is:

> "An area in the northeast portion of a 696.5-acre tract in the Thomas Stevens survey, Abstract #57 (deed from A.S. Fletcher and wife to Duane Sheridan, January 3, 1948, Volume 108/39) in Waller County, Texas, adjacent to the Brazos River and about 2 miles northwest of the intersection of Clarke Bottom Road and FM 1736 in Waller County, Texas".

Sheridan Disposal Service is registered as a corporation with Mr. Duane Sheridan as President, Mr. Pat John Sheridan as Vice President, and Mr. Rupert D. Sheridan as Secretary/Treasurer/Director.

1.1.5 Physiography/Topography - The site has a slope of less than 0.3% to the south-southwest away from the Brazos River. Clark Lake and its intermittent tributaries are the initial collectors of stormwater runoff, with ultimate stormwater drainage being to the Brazos River via Donahoe Creek. Chapter 5 presents a more detailed description of surface water runoff and flood patterns.

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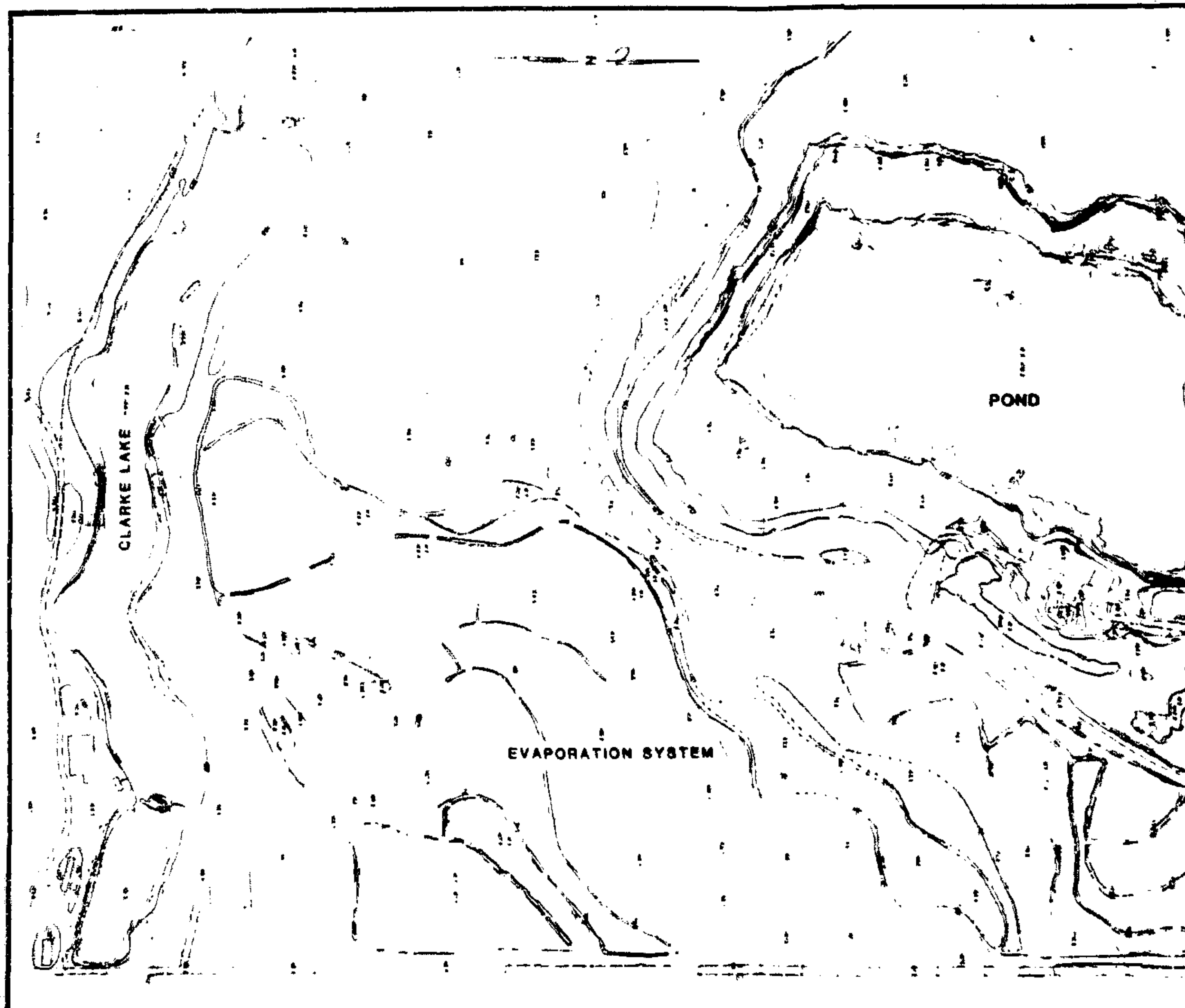

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FIGURE 1-5

SITE TOPOGRAPHY

SHERIDAN DISPOSAL SERVICE

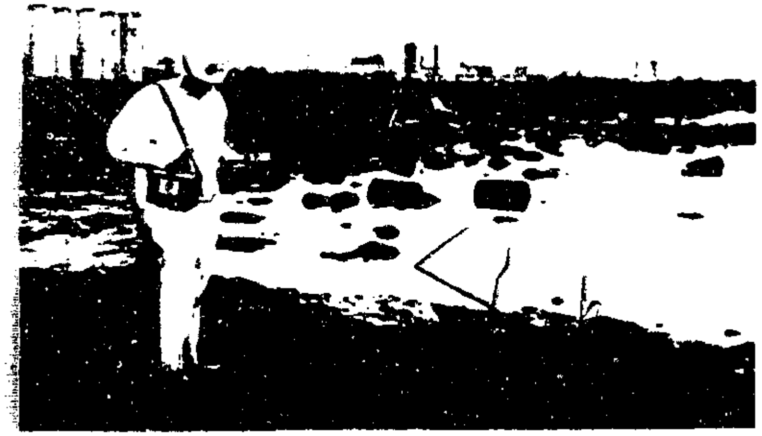
LCS 2/20/86

Figure 1-5 is a topographical survey of the site prepared from aerial photographs in 1984. It should be noted that since that time the evaporation system levees and the pond levees have been strengthened and raised.

1.2 Nature and Extent of the Problem

1.2.1 Waste Quantities and Quality - The major sources of contamination are the pond sludges and contaminated subsoils, the pond levee/dike, and the evaporation system surface soils. Photographs of the pond are shown in Figure 1-6. The extent of contamination in the pond levee/dike, and evaporation system soils, will be further defined in field investigations planned for the Summer of 1987.

The pond contains approximately 105,000 cubic yards of organic sludges which are approximately 50% by weight water and volatile organics, 30% nonvolatile organics and 20% inorganic materials. The priority pollutant organics present are primarily toluene, ethyl benzene, xylenes, benzene, styrene and other aromatics; phenols; and traces of chlorinated solvents such as tetrachloroethylene and trichloroethylene. Polychlorinated biphenyls are present at concentrations up to 223 ppm on a dry weight basis.



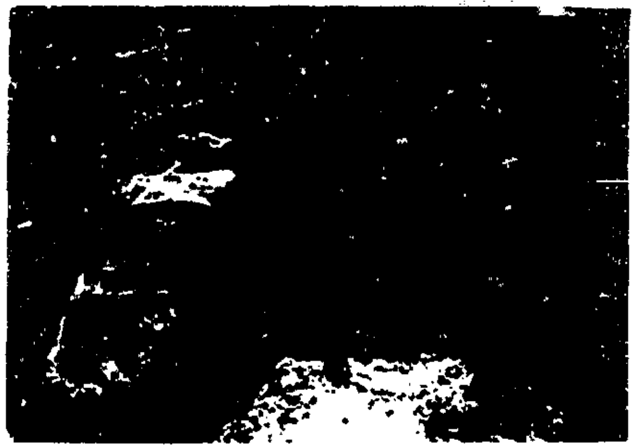


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FIGURE 1-6

IMPOUNDMENT

SHERIDAN DISPOSAL SERVICE

DRAWN BY:	DATE	PROJECT NO.

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Chronic and potential carcinogenic long-term effects will be discussed in the Site Endangerment Assessment. However, a rat oral acute toxicity study was conducted to determine short term effects of the pond sludge in May of 1986. No acute toxic effects were observed at a dosage level of 5050 mg sludge/kg rat body weight. An LD_{50} greater than 5050 mg/kg suggests this material is only slightly acutely toxic.

The pond waste has stratified into a surface oil layer, an aqueous phase and a heavy sludge layer. The surface oil layer (less than two inches in thickness) currently covers an average of 20% of the pond surface area depending upon wind conditions, and is a significant evaporation barrier. The pond aqueous phase is approximately two feet in depth and currently amounts to about 8 million gallons of stormwater storage. Analysis indicates the pond water is contaminated with the following priority pollutants in decreasing order of concentration: phenol, trichloroethylene, toluene, tetrachloroethylene and isophorone.

The pond levee system was constructed from surrounding clays and combustion residues from waste burning. A significant amount (approximately 10%) of the levee material may be ash residue from a waste stream characterized as a diatomaceous earth filter aid wetted with a petroleum oil.

003413

This filter cake waste contained unspecified organo-metallic chemicals as well as insoluble barium and zinc salts. A umber of drums have been incorporated into the levee structure in the north and west sections.

The evaporation system consists of 42 acres of water retention cells which were constructed in 1976 for evaporative treatment of pond stormwater. The system has reportedly managed more than 40 million gallons of wastewater since 1976. Sampling conducted in 1984 and 1985 by Resource Engineering indicates that the soil has elevated levels of chromium, lead, and zinc at depths ranging to three feet in various cells. As part of the Supplemental Sampling and Analysis Plan (SSAP), additional sampling to depths greater than three feet will be conducted in order to establish the extent of contamination. Analysis to date suggests that the cells closest to the point of stormwater introduction have the highest levels of contaminants. To date priority pollutant organics found were in the evaporation system only in areas of surface sludge contamination, and included: phenol, ethylbenzene, toluene, benzene, 2-4-dimethylphenol, tetrachloroethylene, and N-nitrosodiphenylamine.

The groundwater flow direction of the water table aquifer is predominantly toward the north-northwest and it discharges into the Brazos River. Groundwater flow direction is variable and is dependent on the Brazos River water level.

1.2.2 Near Future Impacts - An ecological survey of the site indicated no detrimental effects upon the flora and fauna due to the presence of the site except for direct surface contact with surface oils in the pond (Chapter 7.0)

A Groundwater Migration Management RI report will address the potential impacts on local drinking water supplies, water table aquifer and the first confined aquifer.

Preliminary evaluations of recent air investigations by the EPA's Emergency Response Team and Resource Engineering indicate that the site does not significantly impact local air quality (Chapter 6.0). This will be further evaluated in the Endangerment Assessment.

The site has been stabilized and stormwater accumulation is being managed by removal of floating oil on the pond. Approximately 20 million gallons of accumulated stormwater has been moved to the evaporation system and evaporated. If left unmanaged, the most significant near future impact would be the potential for discharge of contaminated stormwater from the pond into Clark Lake and the Brazos River. As discussed in Chapter 5.0, stormwater accumulation could result in dike overtopping within 3-5 years, if not managed.

The Brazos River Bank north of the pond is currently eroding at an average rate of less than two feet per

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year. At this rate it will be over 100 years before the river intrudes upon the site.

1.2.3 Past Remedial Actions at the Site - Remedial actions at the site began as early as March of 1975 when SDS received an operating permit from the Texas Air Control Board (TACB) for a liquid waste burner. In addition to direct waste incineration, the system was used as a boiler/evaporator for treatment of the pond waters.

In February, 1976, the Texas Water Quality Board (TWQB) issued amendments to the facility's operating permit. One of these amendments required the facility to meet a schedule for the dewatering and closure of the pond. In May of 1976 Sheridan Disposal Services began operating a TWQB approved 42-acre "evaporation irrigation" system for treatment of the pond waters. The system reportedly treated over 40 million gallons of water during the period from May of 1976 through 1984. Sampling conducted by the TWQB and Resource Engineering indicates that organics and heavy metals were reduced in concentration as the impoundment waters passed through the evaporation system treatment cells primarily through biodegradation, sorption to soils, and evaporation. (See further discussion Section 3.1.3.) Evaporation system treatment of the wastewater prevented major discharges to Clark Lake and the Brazos River as well as possibly preventing a catastrophic failure of the pond dike system.

In April of 1984, the Sheridan Site Committee pursuant to TDWR direction initiated remedial actions at the site. These actions included:

(1) Approximately 11.5 million gallons of pond water were transferred to the evaporation system for on-site management.

(2) The pond and evaporation system dikes were repaired, strengthened and raised.

(3) Approximately 6,000 gallons of floating oils were removed from the pond and placed into on-site tanks.

1.3 Summary of Site Investigations - Numerous investigations have been conducted to identify site conditions. The initial site assessments were conducted by the Texas Department of Water Resources (TDWR) and its predecessors. These assessments consisted of facility inspections and limited sampling beginning in 1962 and increased in scope in later years. Sampling included groundwater, pond sludge, pond water, Clark Lake, and evaporation system water and surface soils. A discussion of the significance of these data is presented in Chapter 3.

In July of 1983, an EPA Field Investigation Team (FIT) conducted a site survey Background data was collected for the Mitre Hazard Ranking System (HRS) model which is used to evaluate site eligibility for inclusion on the National Priorities List (NPL) under CERCLA. Various samples from the

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Brazos River, ground water, air, pond, and the evaporation system were analyzed. Chapter 3 contains a review of these data.

Resource Engineering Inc. was retained in February of 1984 by the Sheridan Site Committee to provide technical assistance in developing a closure plan for the site. The following technical reports have been submitted to the Texas Department of Water Resources and, later, Region VI of the Environmental Protection Agency (EPA):

- May 1984, "Sheridan Disposal Site Preliminary Site Assessment"
- July 1984, "Sheridan Disposal Site Additional Site Assessment Data and Closure Concept"
- October 1984, "Aquatic Survey of Clark Lake at Sheridan Disposal Service"
- October 1984, "Permit Application for Construction of a Spur Jetty System on the Brazos River"
- March 1985, "Sheridan Disposal Service, Waste Management Facility Closure Plan and TSCA Chemical Waste Landfill Permit Application"
- August 1985, "Quality Assurance Project Plan for Sheridan Disposal Service Field Activities"
- August 1985, "Hydrogeologic Investigation Plan for Sheridan Disposal Service Field Activities"

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- September 1985, "Sampling and Analysis Plan for Sheridan Disposal Service Field Activities"

The most recent site investigation was conducted from November, 1985 through January of 1986. The field investigation plans were developed in response to EPA's July 15, 1985 technical review of existing site information. Additional site hydrogeologic information and soil characterizations were required to complete this site Remedial Investigation (RI) under CERCLA guidance.

The additional hydrogeologic investigations consisted of:

- Three additional borings in the evaporation system area.
- Three shallow slug test piezometers to determine permeability of upper clay layer (in situ permeability).
- Eight piezometers and two wells in the water table aquifer and the confined aquifer for pump tests to further define aquifer characteristics.
- Weekly static water level measurements during field activities to define ground water flow patterns.

The sampling and analysis investigations consisted of:

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- Sediment sampling of Clark Lake for GC/MS priority pollutants and pesticides.
- Soil sampling of the evaporation system test plot for contaminant indicator parameters of oil and grease and selected heavy metals.
- Sampling of the evaporation system cells to a depth of 3 feet for contaminant indicator parameters and GC/MS analysis of selected samples.
- Background soil sampling and analysis

Following submittal of a draft RI in July of 1986, EPA determined that additional hydrogeologic investigations as well as further soil sampling would be required. A Groundwater Migration Management RI will report on the results of the hydrogeological investigations. A separate report will contain the results of the evaporation system and levee soil sampling.

1.4 Remedial Investigation Report Overview - This Remedial Investigation (RI) report is a summary of all applicable data on the Sheridan Disposal Service Site including the results of field investigations requested by the EPA in June, 1985.

Chapter 2 discusses the site features including local population statistics, land use, surface water uses, groundwater resources, and a summary of local meteorology.

Chapter 3 describes the waste quantities and characteristics at the site. Available analytical data are reviewed for the pond sludge, pond waters, and evaporation system. The chemical fate and transport of the wastes is also discussed.

Chapter 4 details the regional and site specific geology, regional and site-specific hydrology and soil. This chapter provides an interpretation of geologic processes resulting in the depositional sediments which serve as the host geology of the site and an evaluation of site groundwater hydrology and the relationship between the shallow unconfined water table aquifer and the confined aquifer.

Chapter 5 describes the area's surface water hydrology, including stormwater runoff. Analytical results of samples collected from Clark Lake and the Brazos River are discussed.

Chapter 6 reviews available data on atmospheric emissions from the site. Chemical degradation paths of the major contaminants are also reviewed.

Chapter 7 presents the results of recent investigations of the site's fauna and flora. The surrounding ecosystems are described and the potential for the presence of endangered species is reviewed.

Chapter 8 is a review of the site's present impact on public health and a review of existing environmental damage from the site.

Chapter 9 summarizes the more significant results of the Remedial Investigation Report. These data will serve as site documentation from which to prepare a Source Control Feasibiity Study (FS) for ultimate site remediation.

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2.0 SITE FEATURES

2.1 Demography - The Sheridan Disposal Service (SDS) site is located adjacent to the Brazos River in northwestern Waller County, Texas, approximately 9 miles north-northwest of the town of Hempstead. Three smaller communities in Waller County lie within 10 miles of the facility. Deerwood Lakes and Deerwood North are located 6 miles to the east; the Rolling Hills community lies about 8 miles east-southeast of the site. In addition, the town of Prairie View and Prairie View A&M University are located 12 miles southeast of SDS, as shown in Figure 2-1.

Other communities are located in Washington County, which is adjacent to Waller County, separated by the Brazos River. The small community of Brown College, Texas lies closest to the SDS, approximately one and one-half miles north in Washington County. Other communities include Washington, 8 miles to the north-northwest, and Chappell Hill, 9 miles to the southwest. Another community within 10 miles of SDS is Courtney, located about 5 miles to the northeast in Grimes County.

Demographic information was compiled for an area of approximately 12 miles in radius (450 square miles) around the SDS site. This includes the towns of Hempstead, Prairie View,

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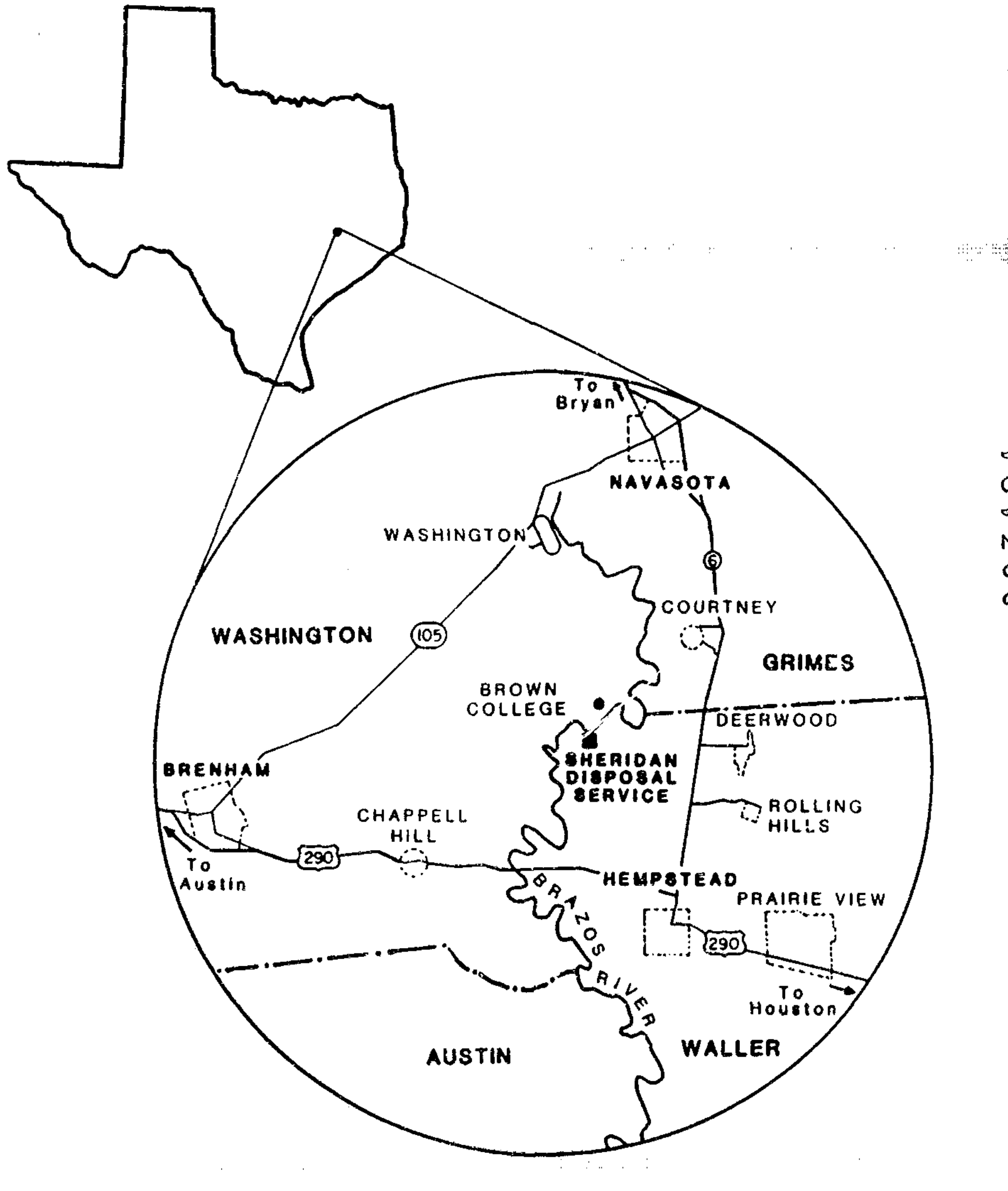

0 5 10
SCALE (MILES)

RESOURCE ENGINEERING INC.
REI
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HOUSTON, TEXAS

FIGURE 2-1
REGIONAL COMMUNITIES
SHERIDAN DISPOSAL SERVICE

DRAWN BY: L.M.G.	DATE: 3-3-86	PROJECT NO. 288-04

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Chappell Hill, and Washington. All data was obtained from the Donnelly Demographics data base using DIALOG Information Services (1986). A data summary is provided in Table 2-1.

The 1985 estimated population for the area within 12 miles of the SDS site is 15,527; this is an average of 35 people or 12 households per square mile, and a 23 percent increase from the 1980 census. By 1990, the population is projected to grow by 14.4 percent to approximately 17,767 people, which is equivalent to an average of 39 people or 13 households per square mile. The number of households also increased from 3,545 in 1980 to 5,035 in 1985. An increase in the number of households to 5,890 is estimated by the year 1990. The average household size, 3 people, has remained constant and is not expected to change through 1990.

Over 60% of the residents within the area studied reside within the major towns and communities described, with sparse residences in the large rural areas closest to the SDS site. Only one permanent residence (that of Mr. Sheridan) is located within 1 mile of the site. However, a site caretaker lives in a mobile home approximately 2000' southeast of the pond. The median age of the population varies between Waller and Washington Counties. The towns of Hempstead and Prairie View in Waller County have a median age of 26, while the median age of 34 in Washington and Chappel Hill in Washington County is older. This difference is due to the fact that approximately 20 percent of Washington County's population is 65 or

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Table 2-1

Demographic Information

Hempstead, Texas

	1980 Census	1985 Estimate	% Change 80 to 85	1990 Projection
Total Population	8,072	10,210	26.5%	11,924
Total Households	2,474	3,335	34.8%	3,984
Household Population	6,932	9,326	34.5%	11,040
Average Household Size	2.8	2.8	-.1%	2.8
Median Household Income	$14,429	$19,586	35.7%	$26,259

	1980 Census		1985	1990
	Number	Percent	Estimate	Projection
Total Population By Age	8,072	100.00%	10,210	11,924
0- 5	674	8.3%	9.5%	9.7%
6-13	930	11.5%	11.4%	12.1%
14-17	530	6.6%	8.2%	7.1%
18-24	1,806	22.4%	16.9%	15.6%
25-34	1,079	13.4%	13.7%	14.1%
35-44	666	8.3%	11.1%	12.5%
45-54	665	8.2%	7.5%	8.4%
55-64	663	8.2%	8.3%	7.5%
65 +	1,059	13.1%	13.3%	13.0%
Median Age Total Population	25.7		27.8	28.5
Median Age Adult Population	36.2		39.2	39.6

Table 2-1 (continued)

Prairie View, Texas

	1980 Census	1985 Estimate	% Change 80 to 85	1990 Projection
Total Population	2,266	2,744	21.1%	3,115
Total Households	219	722	229.7%	858
Household Population	586	2,083	255.5%	2,454
Average Household Size	2.7	2.9	7.7%	2.9
Median Household Income	$18,392	$35,712	94.2%	$41,078

	1980 Census Number	1980 Census Percent	1985 Estimate	1990 Projection
Total Population By Age	2,266	100.0%	2,744	3,115
0- 5	45	2.0%	6.8%	7.0%
6-13	70	3.1%	9.2%	9.1%
14-17	51	2.3%	11.3%	10.0%
18-24	1,734	76.5%	26.8%	24.5%
25-34	69	3.0%	11.7%	12.5%
35-44	54	2.4%	10.8%	11.7%
45-54	90	4.0%	7.9%	8.8%
55-64	83	3.7%	7.1%	7.2%
65 +	70	3.1%	8.3%	9.4%
Median Age Total Population	21.8		23.9	24.8
Median Age Adult Population	22.2		33.1	35.0

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Table 2-1 (continued)
Washington, Texas

	1980 Census	1985 Estimate	% Change 80 to 85	1990 Projection
Total Population	1,195	1,333	11.5%	1,402
Total Households	441	507	15.0%	539
Household Population	1,195	1,333	11.5%	1,402
Average Household Size	2.7	2.9	-2.8%	2.6
Median Household Income	$12,594	$16,524	31.2%	$20,333

	1980 Census Number	1980 Census Percent	1985 Estimate	1990 Projection
Total Population By Age	1,195	100.0%	1,333	1,402
0- 5	112	9.4%	8.6%	8.7%
6-13	118	9.9%	10.4%	11.3%
14-17	89	7.4%	5.6%	5.0%
18-24	106	8.9%	13.1%	9.8%
25-34	157	13.1%	13.9%	17.4%
35-44	96	8.0%	8.6%	10.7%
45-54	138	11.5%	8.8%	7.9%
55-64	135	11.3%	11.5%	10.5%
65 +	244	20.4%	19.7%	18.8%
Median Age Total Population	36.5		33.7	33.4
Median Age Adult Population	50.6		47.3	44.6

Table 2-1 (continued)
Chappell Hill, Texas

	1980 Census	1985 Estimate	% Change 80 to 85	1990 Projection
Total Population	1,095	1,240	13.2%	1,326
Total Households	411	471	14.6%	509
Household Population	1,095	1,233	12.6%	1,319
Average Household Size	2.7	2.6	-1.6%	2.6
Median Household Income	$12,656	$18,846	48.9%	$26,933

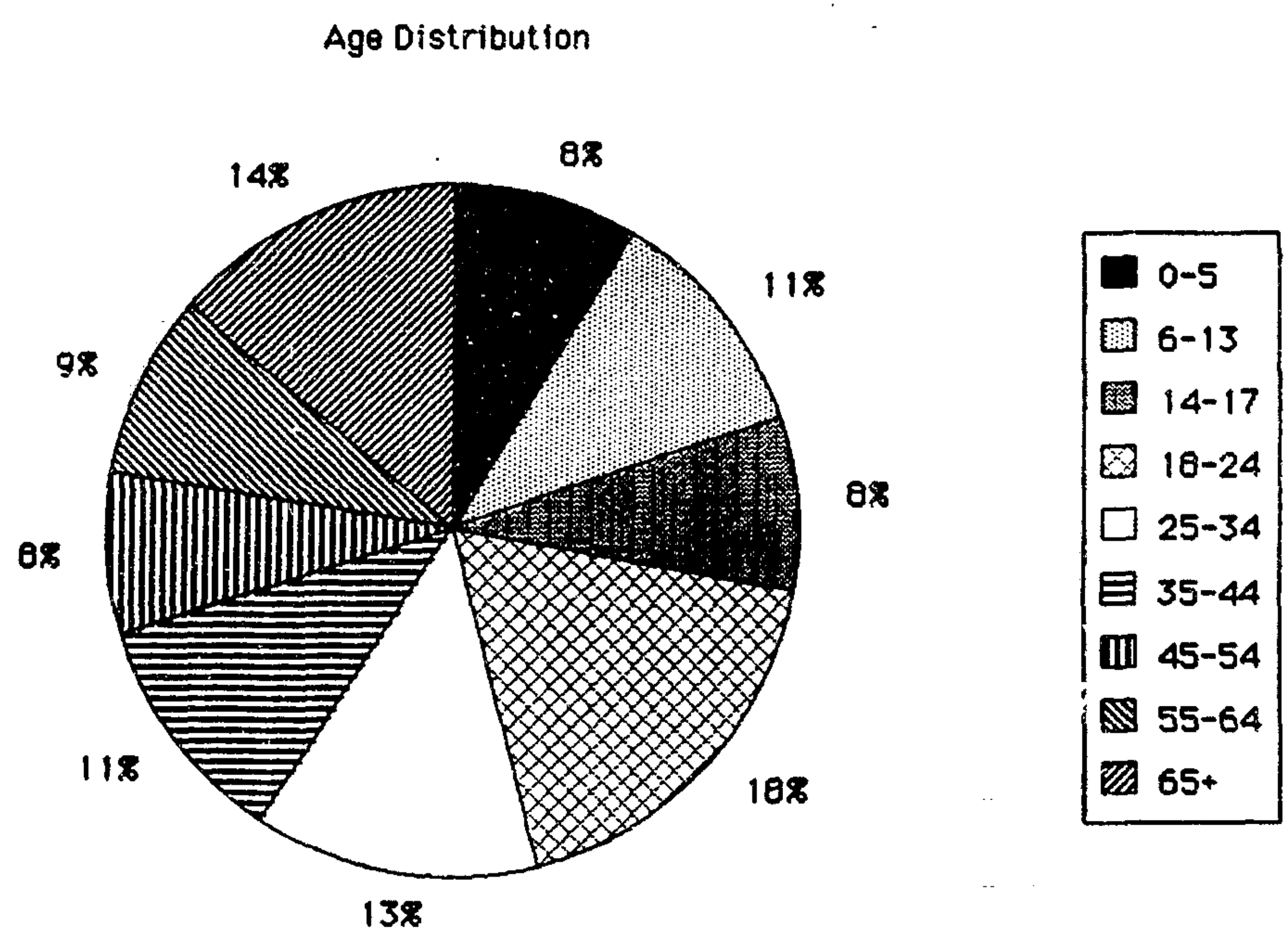
	1980 Census Number	1980 Census Percent	1985 Estimate	1990 Projection
Total Population By Age	1,095	100.0%	1,240	1,326
0- 5	79	7.2%	48.5%	8.6%
6-13	113	10.3%	10.4%	11.3%
14-17	99	9.0%	5.6%	5.2%
18-24	145	13.2%	2.8%	10.0%
25-34	103	9.4%	3.8%	16.9%
35-44	94	8.6%	8.8%	10.9%
45-54	124	11.3%	8.8%	8.1%
55-64	113	10.3%	11.3%	10.3%
65 +	225	20.5%	19.9%	18.8%
Median Age Total Population	35.8		34.0	33.5
Median Age Adult Population	49.7		47.5	44.7

003429

older. Age distribution for the entire area is illustrated in Figure 2-2; the greatest percentage of residents is in the 18 to 24 age bracket, followed by those 65 and older. This population is impacted by college students, who are temporary residents in the Prairie View area.

Prairie View, Texas is the most dynamic of the four towns, with the greatest shift in population distribution. The population has changed from 98.8 percent Black in 1980 to approximately 42 percent in 1985. This decreasing trend is projected to continue through the end of the decade. The race category listed as "other" in the Donnelly Demographics data base is increasing in Prairie View as is the Hispanic community. The demographics indicate that over 75% of Prairie View's residents are of college age (18 to 24 years) and are probably not permanent residents.

A shift in income is also occurring within the four towns closest to the SDS site. Figure 2-3 illustrates the median income for each of these communities for the years 1980, 1985, and 1990. Prairie View's median income increased the most, a 94.2 percent change from 1980 to 1985. Prairie View has the highest median income of the local communities, primarily because of the presence of Prairie View A&M University.



ADAPTED FROM
DONNELLY DEMOGRAPHICS, 1986.

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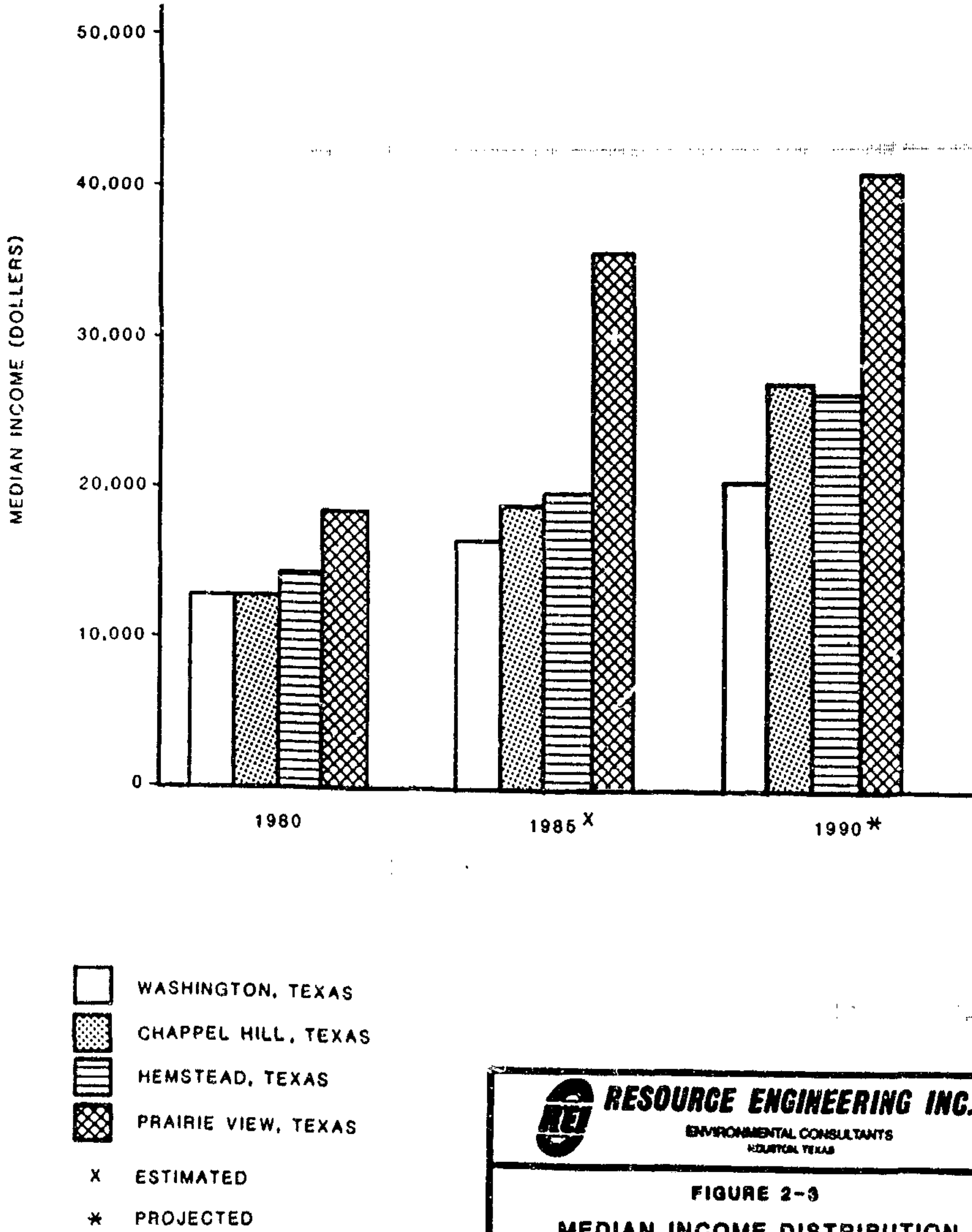
FIGURE 2-2
AGE DISTRIBUTION
WITHIN 450 SQUARE MILES
SHERIDAN DISPOSAL SERVICE

DRAWN BY:
DATE:
PROJECT NO. 288-04

003431



ADAPTED FROM DONNELLY DEMOGRAPHICS, 1986

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HOUSTON, TEXAS

FIGURE 2-3

MEDIAN INCOME DISTRIBUTION
SHERIDAN DISPOSAL SERVICE

DRAWN BY:	DATE:	PROJECT NO.
L.C.S.		288-04

003432

In summary, the towns of Hempstead, Prairie View, Chappell Hill, and Washington, Texas are growing at 3% annually. This trend is expected to continue through 1990 and is concentrated in the existing communities. The current agricultural land uses near this site is expected to remain unchanged. Population and income is increasing in all four communities.

2.2 <u>Land Use</u> - Land use within a four-mile radius of the SDS site is agricultural, including pasture and rangeland. Areas used for pasture are devoted primarily to beef cattle. Pasture areas are usually planted in Bermudagrass, Kleingrass, or Bahiagrass. Other sections are cultivated in truck crops, corn, sorghum, and small grains. Land not used for agricultural purposes is left as woodlands, primarily oak and other hardwoods, and comprises approximately one-quarter of the four-mile radius (USDA, 1981 and 1984).

The small community of Brown College, Texas, is the most populated area within the four-mile radius of the SDS site. Approximately 20 houses are sparsely scattered throughout the Brown College area, and there are no other communities or housing developments within the four-mile radius. Other urban land use within the area was discussed in more detail in Section 2-1.

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FIGURE 2-4
LAND USE MAP
SHERIDAN DISPOSAL SERVICE

L.M.G. | 6-5-86 | 288-04

Oil and gas production wells and gravel pits also comprise a small portion of the land use within a four-mile radius of the SDS site. A land use map is provided as Figure 2-4.

2.3 Area Resources

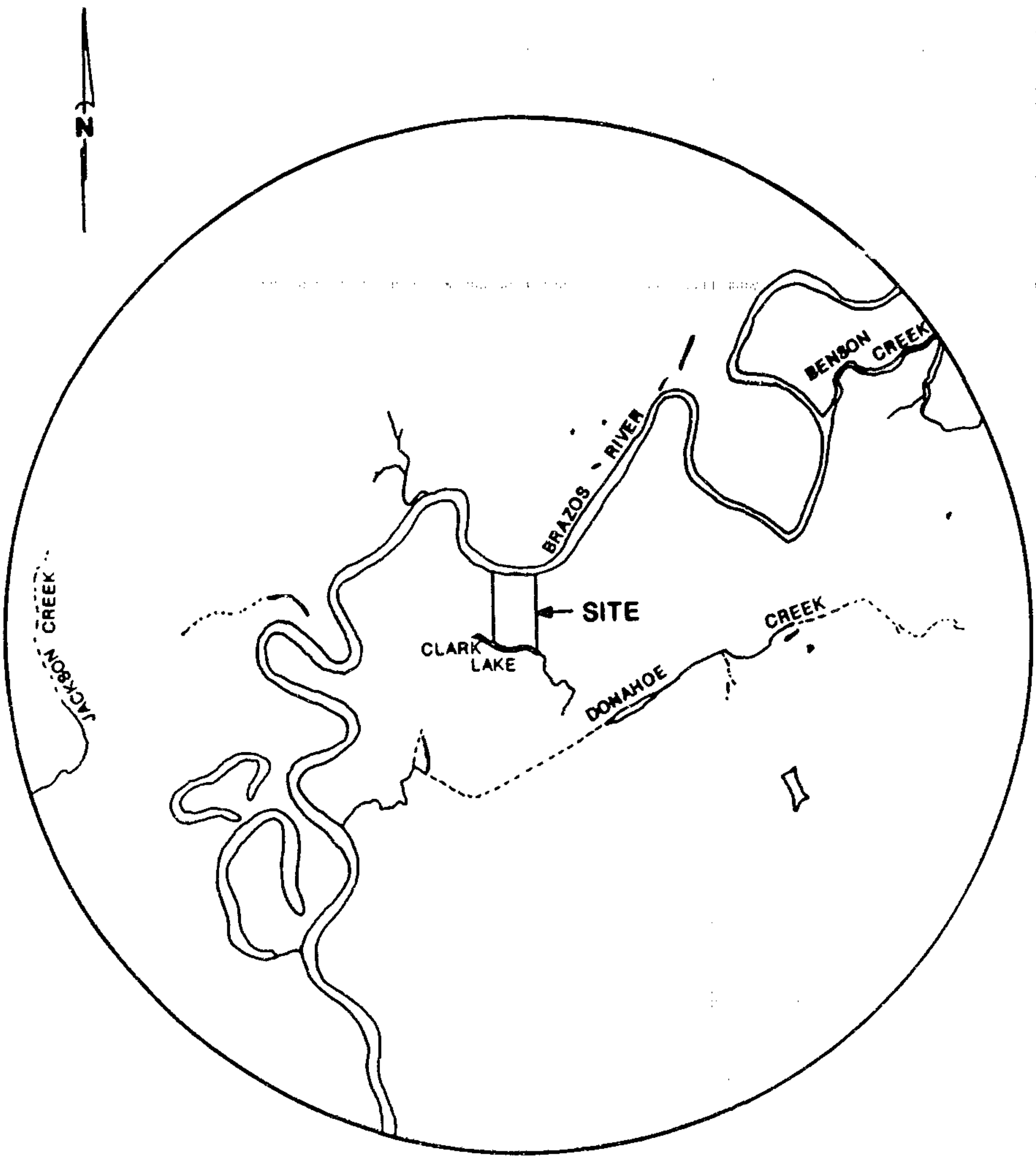
2.3.1 <u>Surface Water</u> - Within a four-mile radius of the SDS site are several bodies of surface water. The Brazos River is the largest and most prominent. There are also small lakes, stock ponds, streams, and marshlands. Location of surface water bodies is provided on the land use map (Figure 2-4).

Brazos River Segment 1202 forms the northern boundary of the SDS site. Segment 1202 of the Brazos River is defined by the TWC as starting at the Navasota River Confluence (approximately 12 miles north of the site) and ending at the FM 521 bridge in Brazoria County. Because of upstream discharges, this segment has been classified as effluent limited by the TWC. Effluent limited river segments require water discharge permits which limit pollutant discharges. Water uses include contact and noncontact recreation, propagation of fish and wildlife, irrigation, and domestic raw water supply. Base flow at monitoring station 1202.0133 is 714.3 cfs (TDWR, 1984).

As of 1984, along Segment 1202 of the Brazos River, 29 municipal and 18 nonmunicipal discharges are permitted. These discharges influence the water quality which includes periodic elevations of fecal coliform bacteria and phosphate. The Water Quality Management Program, State of Texas Water Quality Inventory, TDWR, 1984 stated that "elevated levels of arsenic, chromium, mercury, zinc and aldrin have been found in water (in Segment 1202). The sources and significance of these contaminants have not been determined." Of these contaminants, zinc has been detected at levels of 118 to 13,800 mg/kg and chromium is present at levels of 19 to 302 mg/kg in the pond sludge (Table 3-2). As concluded in Chapters 4 and 5, the site does not adversely impact the water quality of the Brazos River. 003436

The Brazos River is a mature river system characterized by its meandering pattern. Erosion occurs on the outside or concave side of river banks and deposition of material on the convex side, creating U-shaped meanders. Over geologic time, continued erosion cuts the bank so severely that the river flows through the cut bank and isolates the meander. These isolated portions of river become oxbow lakes, named for their distinctive shape.

Within a four-mile radius of the SDS site are two oxbow lakes, both approximately 2.5 miles to the southwest as shown in Figure 2-5. Smaller lakes close to the Brazos River, such as Clark Lake, may be remnants of older oxbow lakes.



0 1 2
SCALE (MILES)

RESOURCE ENGINEERING INC.
ENVIRONMENTAL CONSULTANTS
HOUSTON, TEXAS

FIGURE 2-5
SURFACE WATER
SHERIDAN DISPOSAL SERVICE

DRAWN BY: LMG	DATE: 3-10-87	PROJECT NO. 288-04

Clark Lake, created by 2 man made dams in a natural drainage channel, borders the SDS site on the south and is used as a water supply for livestock. To the southeast of the SDS site, Donahoe Creek is dammed to form a small lake. Scattered throughout the four-mile radius are several small lakes and stock ponds (USGS, 1961 and 1979).

Five streams are located within a four-mile radius of the Sheridan Disposal Services property. Beason Cedar Creek is located 3.2 miles northeast of the facility; Donahoe Creek is located 1.3 miles to the south; and Walnut Bayou borders the four-mile radius to the south. All three of these streams flow from east to west and discharge into the Brazos River.

Doe Run, 1.2 miles northwest of the SDS site, also discharges into the Brazos River on the west bank. Jackson Creek lies approximately 3.5 miles west of the facility. This stream flows south into Red Gully which discharges to New Years Creek and eventually into the Brazos River.

Four marshlands lie within the vicinity of the SDS site. One is located 3000 feet east of the site boundary; two others are 2.5 and 3 miles to the south; and the last lies about 2.7 miles to the west (USGS, 1961 and 1979). Many surface waters in the area provide habitat for water fowl during the winter months. An extensive discussion of natural habitats is provided in Chapter 7.

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2.3.2 Groundwater - Groundwater is an important resource in the area, providing most of the water to meet Waller County's needs. Groundwater uses include irrigation, public supply, industrial, rural, domestic and livestock. Irrigation of rice fields and pasture, and water for livestock, are the primary agricultural uses of groundwater supplies. Industrial uses include oil and natural gas production (Texas Water Development Board, 1967).

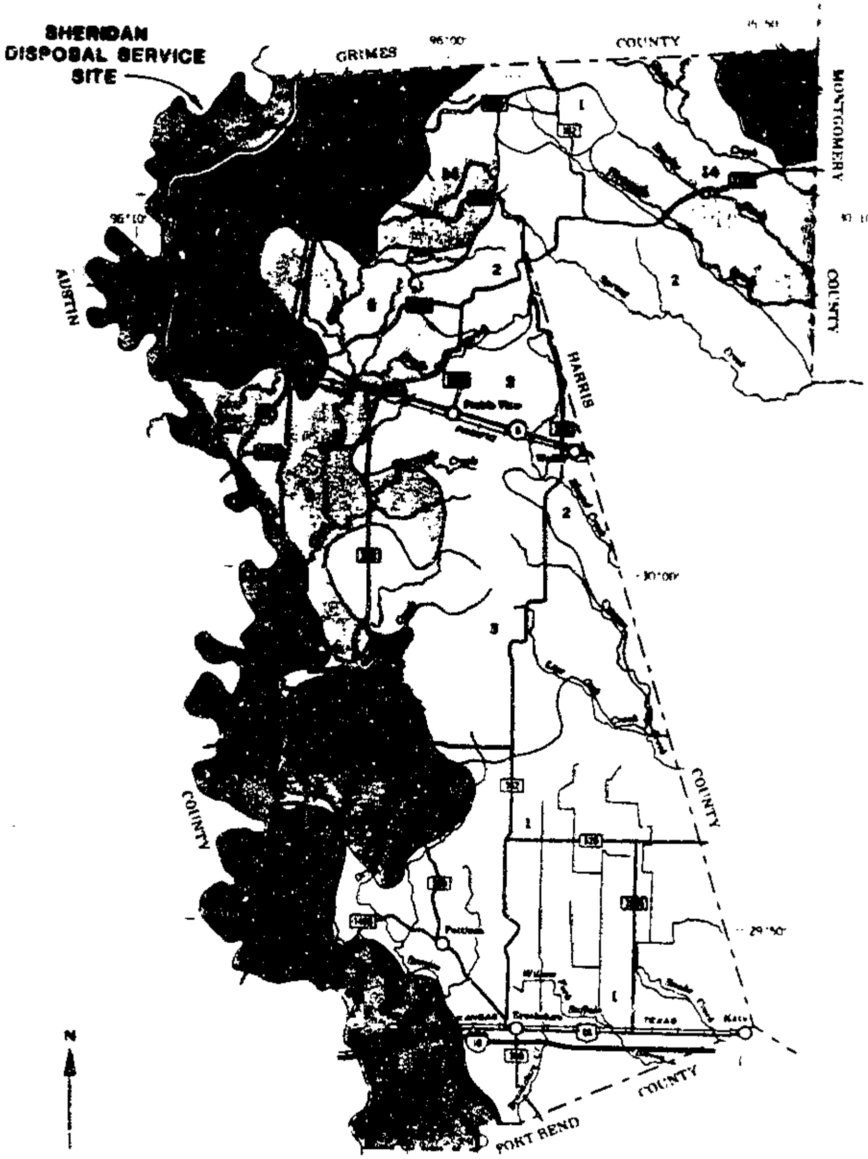
The Jasper and Evangeline aquifers are the primary groundwater resources in the region. Most water wells in the region are drilled into the Evangeline aquifer which contains good quality water. The Jasper aquifer is the deepest regional aquifer beneath the SDS site. Only a few large capacity wells have been drilled into the Jasper formation within a four-mile radius of the site and its hydrology is not fully characterized. Water quality of the Jasper aquifer is fresh to saline. The salinity increases with depth (generally over 1000 feet).

Limited amounts of groundwater are withdrawn from the Burkeville aquiclude and Brazos River alluvium. The Brazos River alluvium varies significantly in water production depending on site specific stratum. The Burkeville aquiclude is a clay formation between the Jasper and Evangeline aquifers that contains thin sand lenses. These sand lenses are used for a few domestic and irrigation wells.

The Brazos River alluvium is tapped for additional irrigation water for row crops and pastures. These wells range in total depth from 75 feet to 80 feet (Texas Water Development Board, 1967). A more extensive review of the regional hydrogeology is provided in Chapter 4.

2.3.3 Soil - Much of the economic base of Waller County is agriculture. Food and fiber products as well as livestock all depend upon the soil resource of the area. Figures 2-6 and 2-7 map the soil associations for Waller and Washington Counties, respectively. Within a four-mile radius of the SDS site are eight soil associations--three in Waller County and five in Washington County. Each association will be discussed briefly. Soil series within the SDS site boundaries are described more fully in Chapter 4.

Soil found in bottom lands and flood plains include the Brazoria-Norwood association which includes 55 percent Brazoria, 15 percent Norwood, and 30 percent minor soil series. The Brazoria soil series is a reddish-brown clay to a depth of 80 inches. Near the river channel, but higher in elevation than the Brazoria, is the Norwood soil series. This



LEGEND

(NOT ALL SOIL ASSOCIATIONS OCCUR IN BOTH COUNTIES)

LOAMY AND SANDY SOILS OF PRAIRIES

1 — Katy association. Nearly level to gently sloping, somewhat poorly drained loamy soils

2 — Hockley-Wockley-Monaville association. Nearly level to gently sloping, moderately well drained and somewhat poorly drained loamy and sandy soils

3 — Wockley-Hockley association. Nearly level to gently sloping, somewhat poorly drained and moderately well drained loamy soils

SANDY AND LOAMY SOILS OF SAVANNAHS

Tabor-Tremona-Chazos association. Gently sloping to sloping, moderately well drained and somewhat poorly drained, loamy and sandy soils

6 — Kenney-Tabor-Chazos association. Gently sloping to sloping, well drained and moderately well drained sandy and loamy soils

Cellio-Tremona association. Nearly level to sloping, moderately well drained and somewhat poorly drained, sandy soils

CLAYEY AND LOAMY SOILS OF FLOOD PLAINS

Brazoria-Norwood association. Nearly level to gently sloping, somewhat poorly drained and well drained, clayey and loamy soils

8 — Trinity association. Nearly level, somewhat poorly drained, clayey soils

CLAYEY AND LOAMY SOILS OF BLACKLANDS

Frelsburg-Latium-Crockett association. Gently sloping to strongly sloping, well drained and moderately well drained, clayey and loamy soils

Klump-Carbengle-Brenham association. Gently sloping to sloping, well drained, loamy soils

11 — Frelsburg-Bleiblerville-Latium association. Gently sloping to strongly sloping, well drained and moderately well drained, clayey soils

12 — Wilson-Burleson association. Nearly level to gently sloping, somewhat poorly drained and moderately well drained, loamy and clayey soils

CLAYEY AND LOAMY SOILS OF PRAIRIES

Lake Charles-Midland-Bernard association. Nearly level to gently sloping, somewhat poorly drained and poorly drained, clayey and loamy soils

SANDY AND LOAMY SOILS OF TIMBERLANDS

Depcor-Splendora-Boy association. Nearly level to gently sloping, moderately well drained and somewhat poorly drained, sandy and loamy soils

Conroe-Landman association. Gently sloping to strongly sloping, moderately well drained, sandy soils

* Texture terms refer to the surface layer of the major soils

Compiled 1982

Scale 1:253,440

0 1 2 3 4 Miles

0 4 8 Km

SOURCE: WALLER COUNTY SOIL SURVEY, SOIL CONSERVATION SERVICE, USDA

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FIGURE 2-6
GENERAL SOIL MAP
WALLER COUNTY, TEXAS
SHERIDAN DISPOSAL SERVICE

DRAWN BY:	DATE	PROJECT NO.

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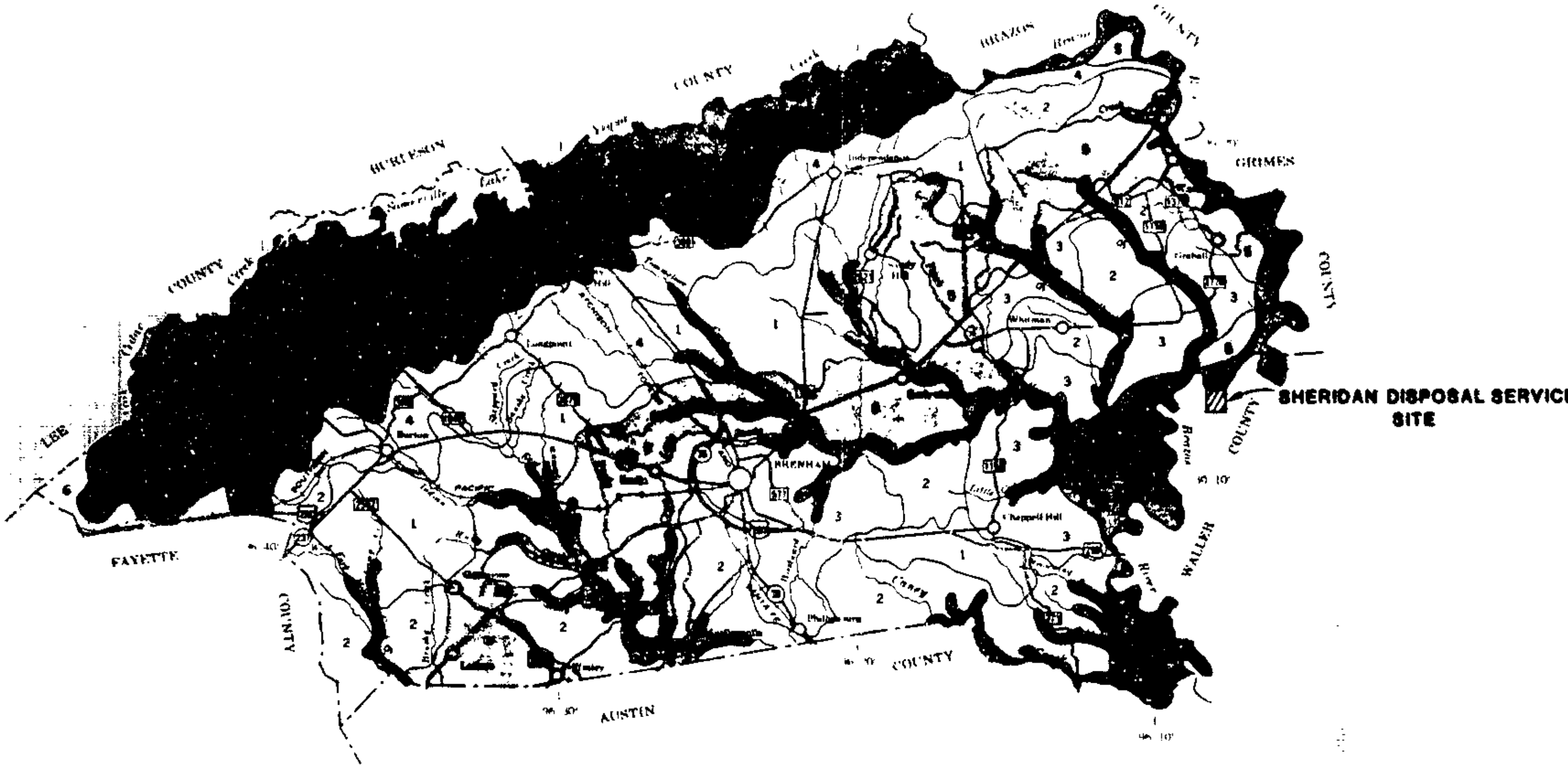

LEGEND*

WELL DRAINED AND MODERATELY WELL DRAINED, CLAYEY AND LOAMY SOILS ON UPLANDS

1 — Bleiblerville-Frelsburg: Deep, gently sloping and sloping, moderately alkaline, clayey soils

2 — Frelsburg-Latium: Deep, gently sloping to strongly sloping, moderately alkaline, clayey soils

3 — Carbengle-Klump: Moderately deep and deep, gently sloping and sloping, slightly acid to moderately alkaline, loamy and sandy soils

4 — Carbengle-Frelsburg-Renish: Deep to very shallow, gently sloping to strongly sloping, moderately alkaline, loamy and clayey soils

MODERATELY WELL DRAINED AND SOMEWHAT POORLY DRAINED, LOAMY AND SANDY SOILS ON UPLANDS

5 — Chiros-Tremona-Crockett: Deep, gently sloping and sloping, medium acid, sandy and loamy soils

6 — Fahn: Deep, gently sloping, slightly acid, very gravelly loamy soils

WELL DRAINED AND SOMEWHAT POORLY DRAINED LOAMY SOILS ON UPLANDS AND TERRACES

Falba-Burlewash: Moderately deep, gently sloping and sloping, strongly acid and very strongly acid, loamy soils

Lufkin-Mabank: Deep, nearly level and gently sloping, strongly acid and medium acid, loamy soils

WELL DRAINED AND SOMEWHAT POORLY DRAINED, CLAYEY AND LOAMY SOILS ON BOTTOM LANDS

Bosque-Trinity: Deep, nearly level, moderately alkaline, loamy and clayey soils

Brazoria: Deep, nearly level, moderately alkaline, clayey soils

Kaufman-Gowen: Deep, nearly level, mildly alkaline and neutral, clayey and loamy soils

*The soil reaction and texture noted in the descriptive headings applies to the surface layer of the major soils. The soil reaction shown is typical for the series.

Scale 1:253,440

1 0 1 2 3 4 Miles

1 0 4 8 Km

N

SOURCE: WASHINGTON COUNTY SOIL SURVEY SOIL CONSERVATION SERVICE, USDA

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ENVIRONMENTAL CONSULTANTS

FIGURE 2-7
GENERAL SOIL MAP
WASHINGTON COUNTY, TEXAS
SHERIDAN DISPOSAL SERVICE

DRAWN BY	DATE	PROJECT NO.

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soil contains layers of silty clay loam, silt loam, very fine sandy loam, and clay from the surface to a depth of 72 inches. The minor soils include the Clemville, Oklared, Sumpf, and Nahatche series. Soils of the Brazoria-Norwood association are used for crops, especially corn, and pasture. Pasture areas have been improved with Bermudagrass (USDA, 1984).

The Brazoria Soil Association lies across and along the Brazos River from the SDS site in Washington County. The Soil Survey describes the Brazoria association as "deep, nearly level, moderately alkaline, clayey soils" (USDA, 1981). This association consists of 45 percent Brazoria soil and 55 percent minor soils including Asa, Belk, Clemville, Kiomatia, Norwood, and Oklared soil series. The Brazoria soil is a calcareous clay to a depth of 60 inches with slopes of zero to one percent. Soil uses include crops and pasture, with a high potential for good yields. Pasture areas are especially suited to coastal Bermudagrass (USDA, 1981).

The final soil association located in bottom lands is the Bosque-Trinity, described as "deep, nearly level, moderately alkaline, loamy and clayey soils" (USDA, 1981). This association consists of 40 percent Bosque, 40 percent Trinity, and 20 percent Kaufman soil series. The Bosque soil series contains layers of clay loam, and loam, to a depth of 60 inches. The Trinity soil varies from dark-gray clay to very dark-gray clay to a depth of 80 inches. Both soils are

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calcareous throughout the profile. Soil uses include improved pasture and pecan production. Pasture is improved with Bermudagrass and Kleingrass (USDA, 1981).

Five soil associations are found in upland areas within a four-mile radius of the SDS site. Two particular to savannahs, are the Tabor-Tremona-Chazos and Kenney-Tabor-Chazos soils associations. The Tabor-Tremona-Chazos association is located in Waller County, east and south of the site. Described as "gently sloping to sloping, moderately well drained and somewhat poorly drained, sandy and loamy soils" in the county soil survey, this association consists of 25 percent Tabor, 18 percent Tremona, 12 percent Chazos, and 45 percent minor soil series (USDA, 1984).

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Tabor soils are found on hillsides and consist of fine sandy loam to 15 inches in depth, changing to clay from 16 inches to 69 inches in depth. Located on foot slopes, the Tremona soil series includes layers of loamy fine sand to 26 inches, 22 inches of clay, and 7 inches of sandy clay. The Chazos series is located on ridges and breaks. It contains two layers of loamy fine sand to a depth of 15 inches, underlain with 40 inches of clay. Minor soil series include Axtell, Crockett, Lufkin, Radar, Styx, and Straber.

Native vegetation of the Tabor-Tremona-Chazos association includes tall grasses and scattered hardwoods.

Presently, the area is used mainly for pasture and range. "Some areas are cropped to corn, cotton, forage sorghum, grain sorghum, small grains, and truck crops" (USDA, 1984).

The Kenney-Tabor-Chazos association in Waller County consists of sloping, well to moderately well drained, sandy and loamy soils. This association contains 31 percent Kenney soils, 15 percent Tabor, 8 percent Chazos, and 46 percent minor soil series. Kenney soils are found on ridges and side slopes, and consist of two layers of loamy fine sand to a depth of 62 inches underlain with 18 inches of sandy clay loam. The Tabor and Chazos soil series are described above. Minor soil series within this association include Axtell, Monaville, Nahatche, Roda, Styx, and Tremona.

Tall bluestem, Indiangrass, shrubs, and scattered oak are the dominant native vegetation. The Kenney-Tabor-Chazos soil association is used mainly for pasture and crops. Pasture areas are planted in coastal Bermudagrass and Bahiagrass while watermelons, truck crops, peanuts, and corn are the major crops grown. Grazing is carried out in wooded areas (USDA, 1984).

In Washington County, three upland soil associations are found within the four-mile radius of the SDS site. The Carbengle-Klump association is described as "moderately deep and deep, gently sloping and sloping, slightly acid to moderately alkaline, loamy and sandy soils" (USDA, 1981). Slopes range from one to eight percent. Thirty percent of the association is Carbengle series, 25 percent Klump, and 45 percent minor soils such as Bosque, Brenham, Cuero, Frelsburg, Knolle, and Renish.

The Carbengle soil series contains 34 inches of calcareous clay loam underlain with greater than 34 inches of sandstone. The Klump soil consists of three layers: 1) a loamy sand to 13 inches; 2) sandy clay loam from 13 to 50 inches; and 3) sandy loam below 50 inches. These layers range in pH from slightly to strongly acid. The area is cultivated in native and improved grasses, and is suited to Bermudagrass, Kleingrass, and Bahiagrass. This soil association has a medium crop potential.

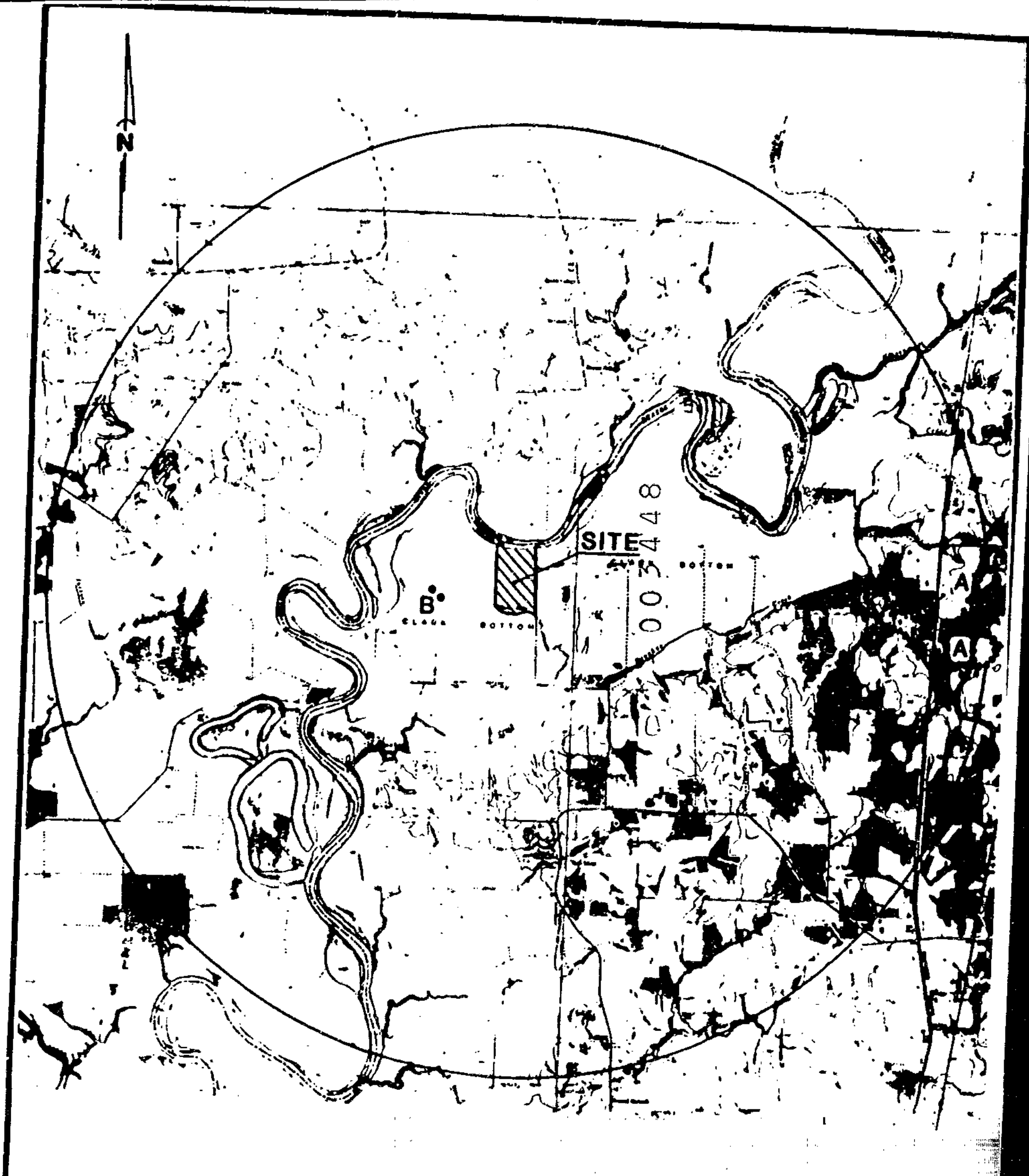
The Frelsburg-Latium soil association consists of moderately alkaline, calcareous, clay soils. Slopes range from 1 to 12 percent. The association contains 35 percent Frelsburg soil, 35 percent Latuim, and 30 percent minor soils including Bleiblerville, Brenham, and Trinity. Both the Frelsburg and Latuim series are clay throughout the soil profile. Most of these soils are cultivated in improved and native pasture with species previously mentioned.

The final soil association within a four-mile radius of the SDS site is the Chazos-Tremona-Crockett. This association contains deep, sloping, medium acid, sandy and loamy soils. Slopes range from 1 to 8 percent. The Chazos series makes up 25 percent of the soils, Tremona 15 percent, Crockett 15 percent, and minor soils 45 percent. Chazos and Tremona soil series were described previously. Crockett soils consist of fine sandy loam to a depth of 7 inches, underlain with a clayey subsoil to 60 inches in depth. Minor soil series in this association include Axtell, Padina, Silawa, and Tabor. The area is used for improved pasture and rangeland, while small areas are cultivated in truck crops.

2.3.4 Other Resources - Other natural resources of importance to the area are sand and gravel, and oil and natural gas. A few sand and gravel pits are located near the Brazos River. The closest mining of these materials to the SDS site is located approximately four miles east, as indicated in Figure 2-8.

Oil and gas production is limited in northwestern Waller County and eastern Washington County. More extensive fields with higher annual production are located in southern Waller County near Katy, Texas. Approximately 3000 feet west of the SDS property boundary are two natural gas production wells.

2.4 Climatology - The climate of the Sheridan Disposal Services site is generally maritime, characterized by hot summers and cool winters with fairly uniform precipitation



A - GRAVEL PITS

B - NATURAL GAS WELLS

0 1 2
SCALE (MILES)

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HOUSTON, TEXAS

FIGURE 2-8
AREA RESOURCES
SHERIDAN DISPOSAL SERVICE

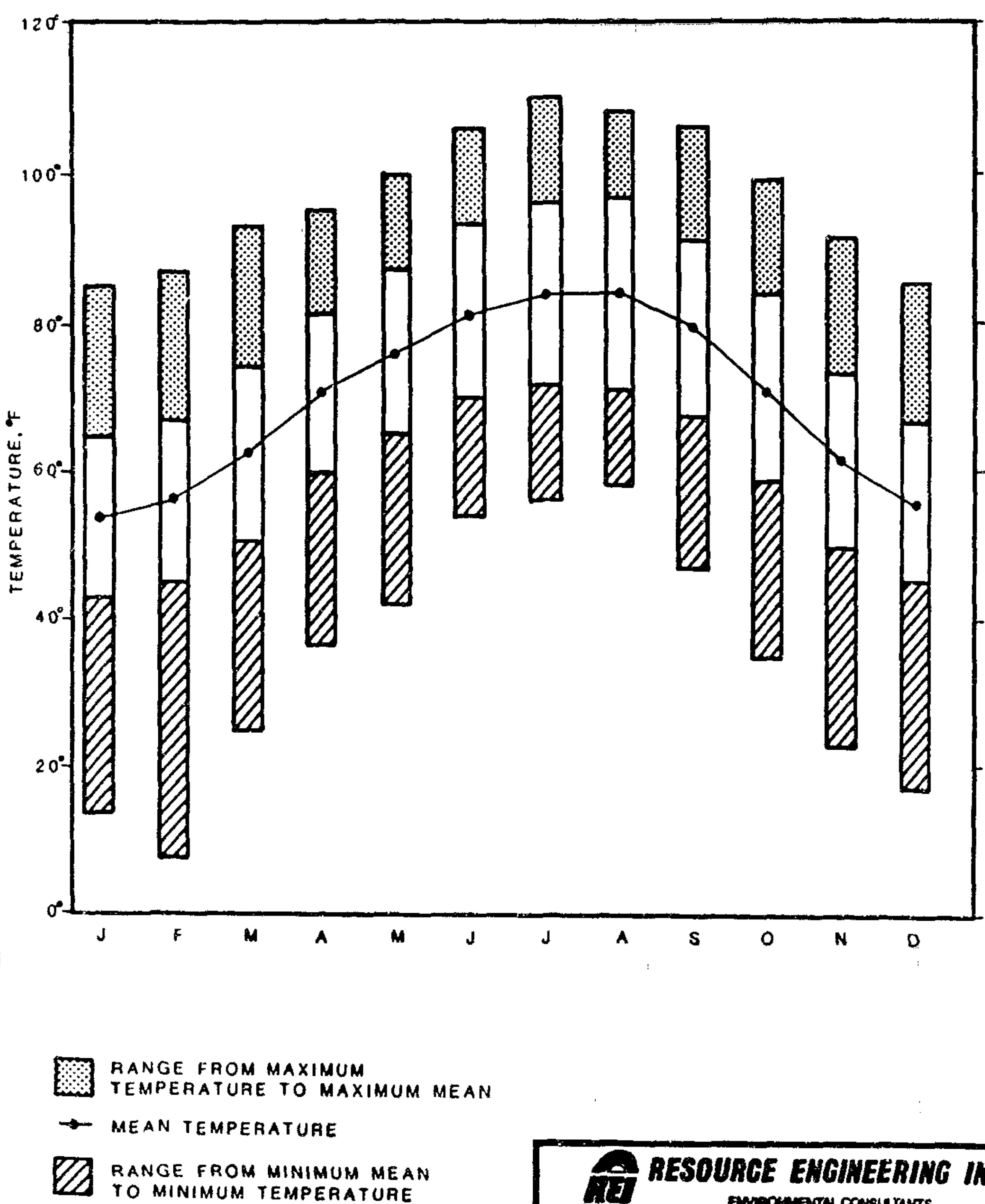
DRAWN BY: L.M.G.	DATE: 5-12-86	PROJECT NO. 288-04

throughout the year. During the winter, occasional surges of polar air cause in a drop of normally mild temperatures. Precipitation "is uniformly distributed throughout the year," with peak rainfall occuring in the spring and autumn (USDA, 1984). Snowfalls are rare in the area.

Temperatures in the winter average 55 degrees F with an average daily minimum of 44 degrees F. During the summer months, the average temperature is 83 degrees F with an average daily maximum reaching approximately 95 degrees F (USDA, 1984). Temperatures of more than 100 degrees F have been recorded for the months of June through September (NOAA, 1982). Figure 2-9 shows the monthly range of average temperatures and record highs and lows.

Relative humidity for the area averages about 60 percent by mid-afternoon and increases during the night to reach a maximum of 90 percent at dawn. The prevailing wind direction is from the south-southeast, averaging about 9 miles per hour (USDA, 1984). A wind rose is provided in Figure 2-10. Meterological data is taken from the closest available locations and is representative of regional conditions.

Total precipitation averages approximately 40 inches per year with monthly averages ranging from 2.08 inches to 4.75 inches. The wettest months are February, April, May, June, September, October, and December, as illustrated in Figure 2-11. Thunderstorms are common during the summer; occasionally



SOURCE: SOIL SURVEY, 1984
AND NOAA, 1982.

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FIGURE 2-9
TEMPERATURE RANGES
AT SEALY, TEXAS

DRAWN BY: L.C.S.	DATE: 2/27/86	PROJECT NO. 288-04

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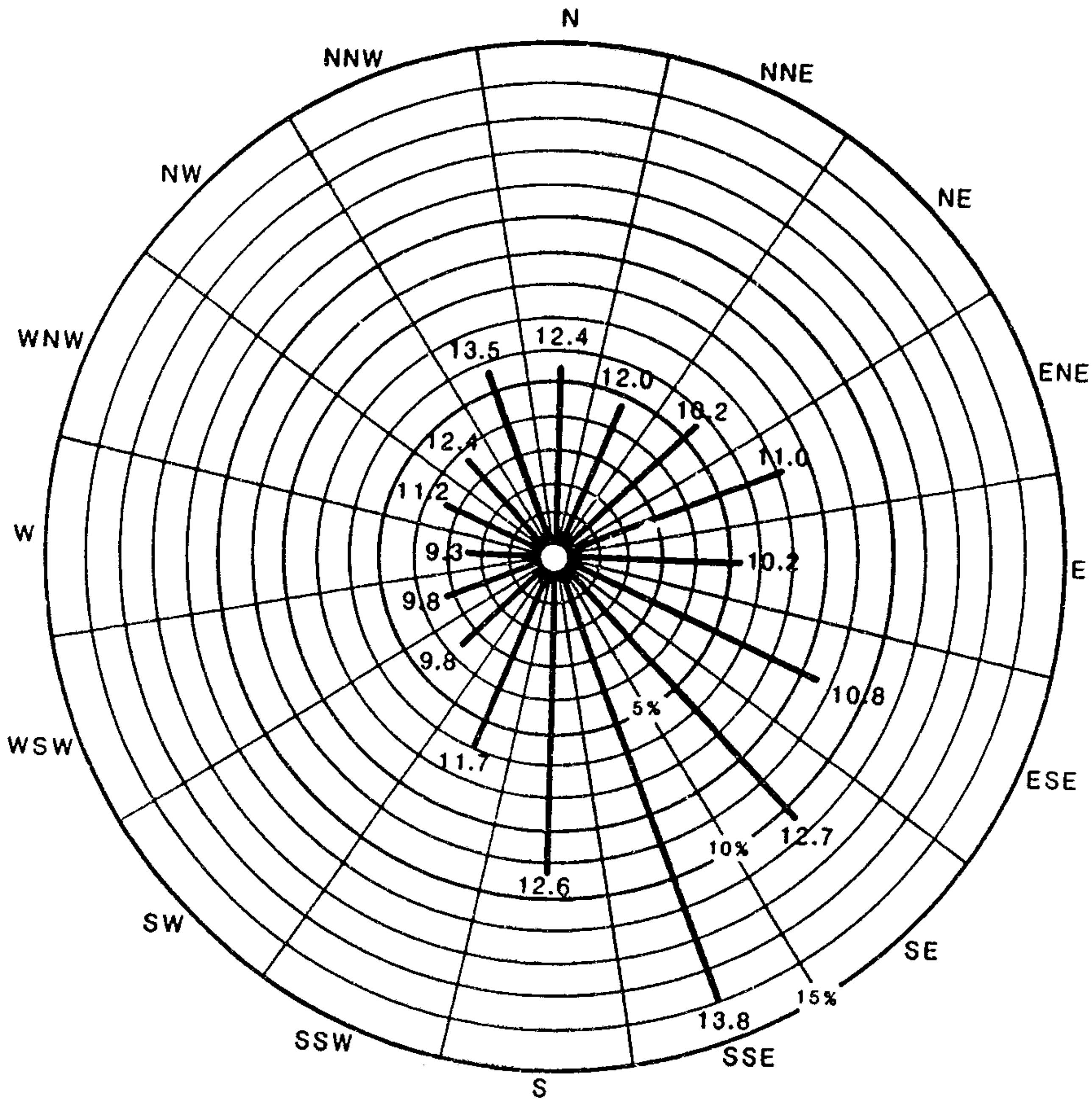

NOTES:

1. LENGTH OF BAR INDICATES PERCENT FREQUENCY OF OCCURENCE OF WIND FROM THAT DIRECTION.

2. NUMBER IS THE AVERAGE SPEED IN M.P.H.

3. NUMBERS ARE BASED ON RECORDS FOR THE PERIOD 1951 THRU 1960 AT HOUSTON INTERNATIONAL AIRPORT (HOBBY AIRPORT).

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HOUSTON, TEXAS

FIGURE 2-10
ANNUAL WIND ROSE
HOBBY AIRPORT

DRAWN BY: L.M.G.	DATE: 2-10-86	PROJECT NO. 288-04

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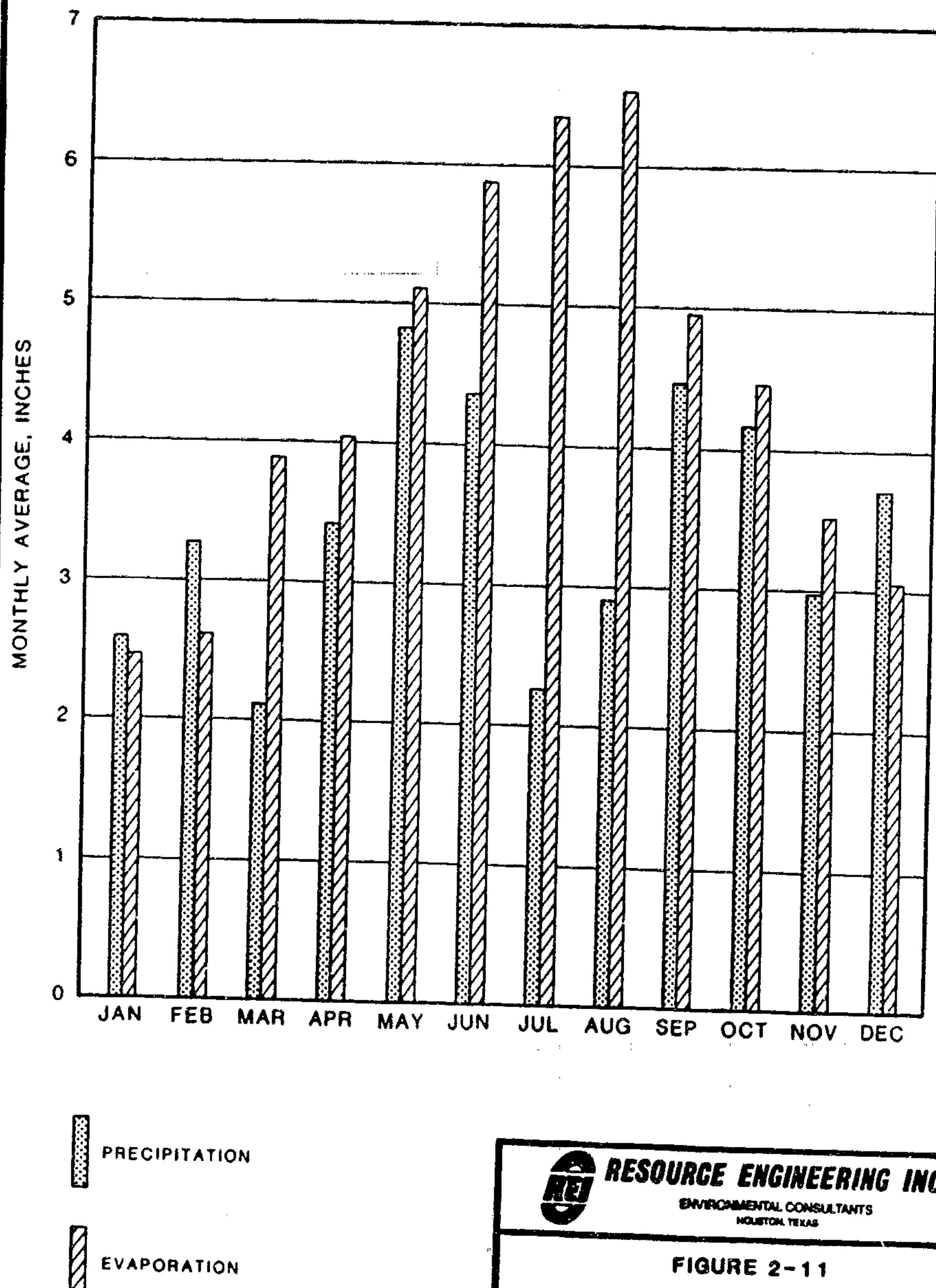

SOURCE: USDA, 1984 AND TWDB, 1975.

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HOUSTON, TEXAS

FIGURE 2-11
PRECIPITATION & EVAPORATION
SEALY, TEXAS

DRAWN BY: L.M.G.	DATE: 2-8-86	PROJECT NO. 288-04

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violent weather, such as tornadoes and severe thunderstorms occur. There is adequate annual precipitation for cotton, small grains, and feed grain production in the area (USDA, 1984).

Net precipitation allowing for evaporation for the area is approximately -15 inches per year, calculated from average annual rainfall and average evaporation rates (USDA, 1984; TWDB, 1975). Rainfall usually exceeds evaporation in the winter months as shown by the bar graph in Figure 2-10. Climatic effects on surface water runoff and storage will be discussed in further detail in Chapter 5.

References - Chapter 2

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3.0 HAZARDOUS SUBSTANCES INVESTIGATION

Sheridan Disposal Services (SDS) operated a commercial industrial waste disposal facility for approximately 25 years beginning in the late 1950s. The facility's operations included open pit burning, surface impoundment disposal, land irrigation/evaporation treatment of impoundment wastewaters and incineration/evaporation of liquid wastes and impoundment wastewaters.

SDS accepted a wide range of wastes from a broad cross-section of Gulf Coast industries. Sources of records on waste types and volumes generally include: SDS operating reports to the state regulatory agencies and shipping manifest records. A survey of the available records indicates 217 generators have contributed waste to the site, and 43 transporters shipped the wastes.

Table 3-1 lists of general waste descriptions found in manifests and other records. These descriptions show that a wide range of petrochemical and general industrial wastes were disposed of at the site. From available records it is estimated that the total amount of wastes received by the Sheridan Disposal Services site exceeds 85 million gallons.

The major waste management areas were the pond impoundment, pond levees, process equipment on the pond levees and the evaporation system. Figure 3-1, a site plot plan, illustrates the locations of these areas. The results from remedial investigations of the volumes and waste

Table 3-1

Manifest Descriptions of Waste Types

Alcohol, organic phosphorus compounds, cobalt

Alkyl Benzenes

Ammonia Bromate, Water

Barge, RR Tank Car Washings, TNK Washings, & Misc. Chemicals

Benzene, Ethers, Methylchloride

BS&W Oils

Butyl Acrylates

Calcium Arsenate

Caustic and Latex Polymer

Copper Chloride Powder Catalyst

Diethylene Glycol, Resin, w/Toluene

Drilling Muds

Drum Washing Residue

Fatty Acid Esters

Fatty Alcohols

Filter cake Residue

Furfural, Butadiene Copolymer

Glycol Still Bottoms

Herbicides

Hydraulic Oils

Insecticides

Kerosene & Grease

Kitchen Grease & Water

Methacrylate

Molasses & Water

Oily Wastewater

Organic Pond Wastewater

Organic Sludge, Skimming, Kerosene and Mineral Spirits

Phenol Formaldehyde

Pickling Acid

Polyethylene, Diatoamaceous Earth

Process Wastewater

Soap

Sodium

Sodium Hydroxide

Sour Crude Oil

Spent Chlorinated Solvents

Spent Newspaper Inks and Solvents

Styrene & Ethylbenzene Bottoms

Styrene Monomer w/Diesel

Vegetable Oils

Waste Chemicals

Water & Oil

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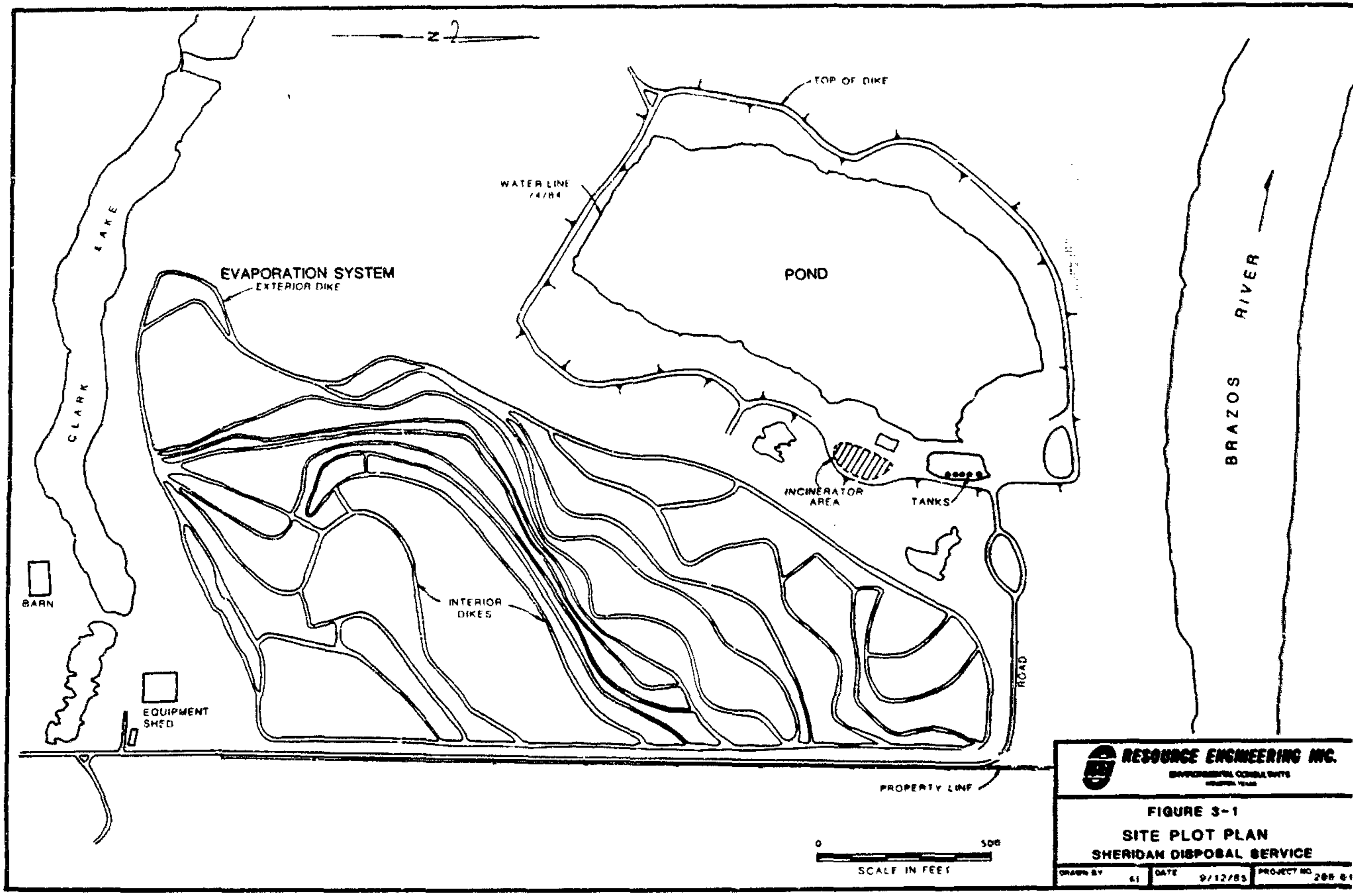

EVAPORATION SYSTEM
EXTERIOR DIKE
POND
TOP OF DIKE
WATER LINE
CLARK LAKE
BRAZOS RIVER
INCINERATOR AREA
TANKS
INTERIOR DIKES
BARN
EQUIPMENT SHED
ROAD
PROPERTY LINE
0
500
SCALE IN FEET
RESOURCE ENGINEERING INC.
FIGURE 3-1
SITE PLOT PLAN
SHERIDAN DISPOSAL SERVICE
DRAWN BY
DATE 9/12/85
PROJECT NO.

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characteristics in these areas are discussed in the following section.

3.1 Waste Characteristics

3.1.1 Pond Impoundment - The pond impoundment was the original waste management area at the Sheridan Disposal Services site. The original waste disposal practice at the site involved open burning of wastes and disposal of any residue in a small, natural depression on the Sheridan property. As the volume of wastes increased, surrounding soils and combustion ash were used to construct a dike around the pond. The pond water surface area has ranged from 12 to 22 acres depending upon the water level and the time period. 0034 58

SDS began initial closure actions in 1979. Approximately five acres of the pond in the north section were covered with construction debris and dike material. An additional two acres of the southeastern portion of the pond were also capped utilizing waste fill and on-site soils. The pond wastes have stratified into three layers: sludge, contaminated stormwater, and a floating hydrocarbon layer.

The pond contains approximately 105,000 cubic yards of sludges; they consist of approximately 50% by weight water and volatile organics, 30% nonvolatile organics, and 20% inorganic materials. See Appendix 3E for calculations. This includes sludge which has seeped into the pond levee or has been covered by closure activities. Surveys conducted by

Resource Engineering in March and May of 1984 (refer to Figure 3-2) and the Texas Department of Water Resources in September 1984 indicated that pond sludge depth ranged from 4" to 3'6" and averaged 2'. Sludge depths in the levee ranged from 4' to 6' based on borings conducted by REI in April of 1984. An average sludge depth of 3' was assumed by volumetrically averaging the pond and levee sludge depths.

Assuming 3 feet of contaminant migration into the subsoils, there is a potential for an additional 60,000 cubic yards of contaminated subsoils beneath the pond sludge. This is an assumption based on the extent of organic and metallic species migration in the evaporative system soils. The EPA has recommended that a conservative estimate in excess of three feet be used in developing remedial options. A conservative estimate of 10 feet of contaminated subsoils is equivalent to approximately 200,000 cubic yards of contaminated soils. Supplemental remedial investigations will provide additional information on the extent of contaminated subsoils.

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Sampling and analysis of the sludge has been conducted by the Texas Water Commission's predecessors, an EPA Field Investigation Team, and by Resource Engineering, Inc. Resource Engineering obtained pond sludges samples in March and May, 1984. Figure 3-2 shows depth of pond sludge and the locations of these sample points. All sludge samples represent composites of the entire sludge layer through to the underlying soils.

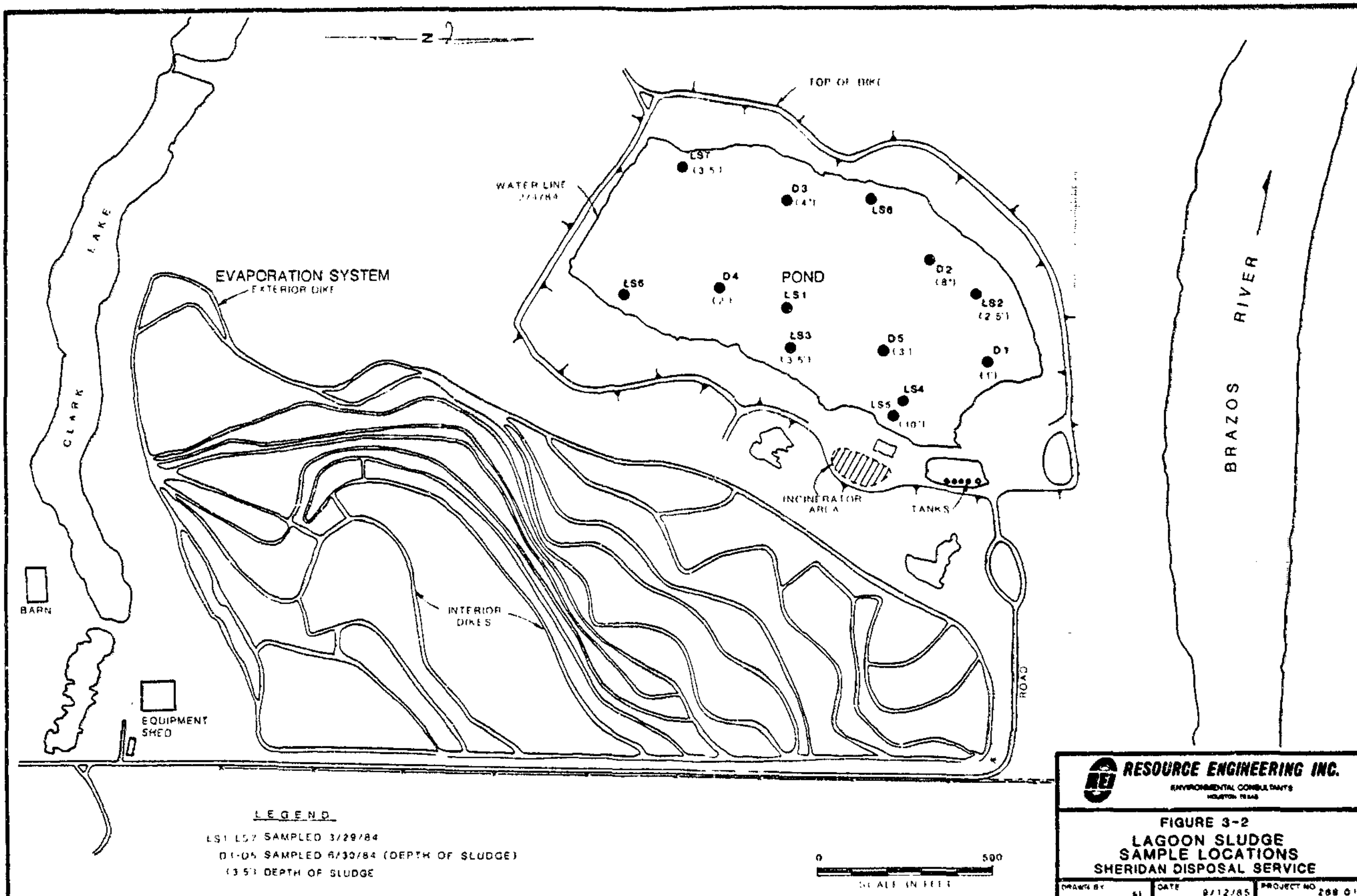
N
TOP OF DIKE
WATER LINE
EVAPORATION SYSTEM
EXTERIOR DIKE
POND
LS7
(3.5')
D3
(4')
LS8
D2
(8')
LS2
(2.5')
D1
(1')
D5
(3')
LS4
LS5
(10')
LS3
(3.5')
LS1
D4
LS6
INCINERATOR AREA
TANKS
INTERIOR DIKES
ROAD
BRAZOS RIVER
CLARK LAKE
BARN
EQUIPMENT SHED
LEGEND
LS1-LS7 SAMPLED 3/29/84
D1-D5 SAMPLED 6/30/84 (DEPTH OF SLUDGE)
(3.5') DEPTH OF SLUDGE
0
500
SCALE IN FEET
RESOURCE ENGINEERING INC.
ENVIRONMENTAL CONSULTANTS
FIGURE 3-2
LAGOON SLUDGE
SAMPLE LOCATIONS
SHERIDAN DISPOSAL SERVICE
DRAWN BY
DATE
9/12/85
PROJECT NO
288 01

Table 3-2 is a summary of available inorganic analysis data on the sludge. The data spans a period from 1973 through 1984. These data are presented for historical purposes and should not be considered directly comparable. Data comparisons must consider the differences in analytical techniques, sampling procedures, preservation techniques, detection limits, and quality assurance procedures utilized over the 12-year period.

Quality assurance/quality control documentation is available only for the May, 1984 Resource Engineering, Inc. and July, 1983 EPA Field Investigative Team (FIT) analyses. Analytical results from the May, 1973 sampling conducted by the Texas Water Quality Board (TWQB) is considered qualitative only due to a lack of QA/QC data. The March, 1976 TWQB data is considered semi-quantitative since QA/QC documentation is not available. The earlier samples obtained by the TWQB were obtained before comprehensive EPA protocols existed for both sampling and analysis procedures. In addition, information on chain-of-custody procedures, samples preservation, and laboratory analytical QA/QC data is not available. Complete laboratory QA/QC data on spike recovery, duplicate analysis, blank results, and equipment calibration is not available for any data prior to 1984.

Table 3-2
Pond Sludge Inorganic Analysis

Constituent	*TWQB May 1973 (Semi-Quantitative) (mg/kg) N.E.	N.W.	S.W.	TWQB March 1976 mg/kg (mg/kg) North	South	EPA FIT Team July/1983 (mg/kg) North end	South end	RET May 1984** Composite (mg/kg)
Aluminum	80,000	90,000	11,000	-	-	2,450	8,790	-
Ammonia	-	-	-	-	-	185	350	-
Arsenic	-	-	-	-	-	2	2	<2
Barium	20,000	20,000	20,000	403.8	647.4	110	125	<100
Beryllium	-	-	-	-	-	-	0.5	-
Boron	400	300	100	-	-	10	15	-
Cadmium	-	-	-	1.9	2.3	0.4	0.4	<2
Calcium	90,000	80,000	90,000	-	-	-	-	-
Chlorides	-	-	-	-	-	-	-	1,640
Chromium	4,000	5,000	2,000	183.1	300.6	22	19	302
Cobalt	200	200	100	-	-	2.5	5	-
Copper	400	400	300	91.1	33.5	17.5	15	388
Iron	60,000	70,000	40,000	-	-	4,270	9,010	-
Lead	2,000	3,000	3,000	537.1	365.3	30	22	<2
Manganese	-	-	-	-	-	154	244	144
Magnesium	40,000	30,000	40,000	-	-	-	-	-
Mercury	-	-	-	-	-	-	-	<1
Molybdenum	200	500	100	-	-	-	-	-
Nickel	1,000	1,000	700	69.5	76.3	90	52	52
Potassium	ND	ND	ND	-	-	-	-	-
Selenium	-	-	-	-	-	-	-	<2
Silicon	90,000	10,000	60,000	-	-	-	-	
Silver	-	-	-	-	-	-	-	<2
Sodium	40,000	40,000	40,000	-	-	-	-	-
Strontium	Trace	Trace	Trace	-	-	-	-	-
Sulfate	-	-	-	-	-	-	-	2,970
Titanium	1,000	1,000	1,000	-	-	-	-	-
Vanadium	-	-	-	-	-	20	20	-
Zinc	-	-	-	633.8	115.6	158	118	13,800

- Not analyzed

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The major, toxic, heavy metals of concern are zinc, chromium, nickel, and lead. The major inorganics are salts of calcium, aluminum, sodium, magnesium, and possibly barium and iron. Inconsistencies in comparing TWQB, EPA and Resource Engineering, Inc. data are believed to be due primarily to the heterogeneous nature of the sludge and differing analytical test procedures. The most recent data are believed to provide the most reliable sludge characterization.

The results of an X-ray diffraction analysis of the pond sludge are presented in Table 3-3. Quartz and cristobalite, feldspar, illite and kaolinite are all common soil minerals. The barium sulfate and calcium sulfate hydrate are salts which were probably introduced with the wastes rather than present as the natural, mineral forms of barite or gypsum. It is important to note the presence of kaolinite clay minerals in the sludge, since they affect heavy metal migration as discussed in Section 3.2.1.

Additionally, the Resource Engineering, Inc. sludge samples of March, 1984 were analyzed by drying at 105°C and ashing at 550°C to obtain a qualitative indication of water and volatile organics, nonvolatile organics and inorganic constituents. Table 3-4 presents these results.

As indicated, the sludges contain approximately 50% by weight water and volatile organics with the "dry weight" composition of the sludges consisting of 60% organic and 40% inorganic materials.

Composites of each set of sludge samples obtained by Resource Engineering, Inc. in March and May, 1984 were analyzed by Gas Chromatography/Mass Spectrometry (GC/MS) for organic priority pollutant compounds. The results are presented in Table 3-5. The major compounds detected were:

- <u>Volatile Aromatics</u> - toluene, ethylbenzene, and benzene;
- <u>Volatile Chlorinated Solvents</u> - tetrachloroethylene, 1,1,1 trichloroethane, and trichoroethylene;
- <u>Phenols</u> - phenol; 2,4, dimethyl phenol;
- <u>Polynuclear Aromatic Hydrocarbons</u> - isophorone, naphthalene, fluorene, phenanthrene and anthracene; and
- <u>Polychlorinated Biphenyls</u> - isomers Aroclor 1242 and Aroclor 1260.

Other organic compounds detected included C_3 and C_2 alkyl-phenols, aromatic hydrocarbons, biphenyl, aromatic ketones, alkyl benzenes and aromatic ethers.

The volatile aromatics are the most significant class of priority pollutants present since their concentrations average an order of magnitude greater than any other priority pollutants. Volatile aromatics represent approximately 5% by weight of the pond sludge composition. Sludge samples from March, 1984 were further analyzed by

Table 3-5

Pond Sludge Priority Pollutant GC/MS Analysis
(mg/kg)

	Resource Engineering, Inc. Data March, 1984 Composite of LS 2,3,5,7,8	Resource Engineering, Inc. Data May, 1984 Composite of D_1-D_5
Volatile Fraction Compounds:		
Benzene	480	>2,500
1,2-Dichloro propylene	-	BMDL <250
Ethylbenzene	740	>8,480
Methylene chloride	-	BMDL <250
Tetrachloroethylene	60	251
Toluene	1750	>36,600
1,1,1 Trichloroethane	-	BMDL <250
Trichloroethylene	100	BMDL <250
Acid Fraction Compounds		
2,4-Dimethyl phenol	580	224
4-Nitrophenol	-	BMDL <83.3
Phenol	1150	1,340
Base/Neutral Fraction Compounds:		
Anthracene	-	33
Benzo(a)pyrene	-	BMDL <32.0
Benzo(b)fluoroanthene	-	BMDL <32.0
Benzo(k)fluoranthene	-	BMDL <32.0
bis(2-Ethylhexyl) phthalate	-	BMDL <32.0
Fluorene	-	55.9
Isophorone	-	99.8
Naphthalene	410	92
Phenanthrene	-	42.8
Pesticide/PCB Fraction Compounds:		
PCB-Aroclor 1242	143	219
PCB-Aroclor 1260	44	ND

- Not quantified
BMDL - Tentatively identified at concentrations below method detection limits.
ND - Not detected

Note: All sludge samples represent composites of the entire sludge layer through to the underlying clay soil.

Resource Engineering, Inc. in April, 1984 to better define PCB types and levels. The results of analysis by Gas Chromatography/Electron Capture techniques for PCBs is presented in Table 3-6.

Table 3-6

Pond Sludge PCB Content (March 1984)

Sample No.	PCB Aroclor 1242 (mg/kg)	PCB Aroclor 1260 (mg/kg)	Total PCBs mg/kg
2	132	0	132
3	81	56	137
5	123	35	158
7	73	76	149
8	154	69	223
Composite	143	44	187

Total PCB levels ranged from 132 to 223 in the sludge samples as shown in Table 3-6. Other samples ranged from below detection limits to 132 mg/kg.

Samples of pond sludge were also analyzed for hazardous characteristics under the technical standards of RCRA. The results are presented in Table 3-7. Based on the hazardous characteristics test results, the sludge, in its present form, would not be classified as a RCRA hazardous waste.

3.1.2 Pond Levee - The levee or dike around the pond has a surface area of approximately 17 acres including portions of the pond which have been previously covered. The levee was constructed from surrounding site soils (predominantly clay and

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Table 3-7

Pond Sludge RCRA Characteristic Analysis

(March, 1984)

Sludge Sample #	Ignitability	Corrosivity (pH)[1]	Reactivity (ppm) Cyanide	Sulfide	RCRA Leachate Metals (ppm) Ba	Hg	Others[2]	Pesticide/ Herbicide[3]
LS#2	I	5.7	1.5	<1	<0.5	<0.005	<0.01	<0.01
LS#3	>220°F	6.5	<1	10.3	<0.5	<0.005	<0.01	<0.01
LS#5	I	6.4	<1	<1	<0.5	<0.005	<0.01	<0.01
LS#7	>220°F	6.4	<1	<1	<0.5	<0.005	<0.01	<0.01
LS#8	>220°F	6.4	<1	<1	<0.5	<0.005	<0.01	<0.01

I - Insufficient sample for analysis

(1) - Extracted in distilled water

(2) - Includes As, Cd, Cr, Pb, Ag, and Se,

(3) - Each of: 2,4-D; 2,4,5-TP; Lindane, Aldrin, Endrin, P,P'-DDT, Methoxychlor, and Toxaphene

clayey soils) sludge, and ash residue from the incineration process). The elevation at the top of the levee varies from 176.5 to 185 feet above mean sea level.

The treatment processes at the SDS site are located on the top of the levee. The treatment units included a receiving pond, an incinerator/ evaporator, a boiler, and a battery of 9 storage tanks. The storage tanks were used for separation and treatment of oil/water emulsions and storage of solvents and fuel oils. According to an as-built site plan prepared by O'Malley and Clay Inc. (September 12, 1972) for SDS, the tanks vary in size from 500 to 1000 barrels. The tanks presently contain from 3 to 7 cubic yards each of bottom sludges which appear to have characteristics similar to the pond sludge based on observations of the tank sludges and discussions with Mr. Sheridan. A composite sample will be tested during preparation of the feasibility study.

Partial closure actions initiated by SDS have resulted in portions of the pond being covered with materials such as construction debris and soils that are different in composition from the remainder of the levee. The levee may contain ash combustion residues as well as steel drums. Additional levee soil sampling will further define contamination levels.

In May, 1984 Resource Engineering, Inc. evaluated the stability of the existing levee system. Appendix 5D contains the results of that evaluation based upon cone penetrometer tests and soils analysis. Quantification of the slope stability is difficult to estimate due to the variety of materials in the levee and the lack of documentation on the construction techniques. However, recent slope stability computer analysis indicates adequate margins of safety exist due to recent remedial actions which strengthened the levee system. Results of computations using the Simplified Bishop Slope Stability Analysis method are presented in Appendix 5D and discussed further in Chapter 5.

3.1.3 Evaporation System - The evaporation system was developed as an on-site management method for excess pond stormwater accumulation. In March, 1975, the Texas Water Quality Board (TWQB), a predecessor of the Texas Water Commission (TWC), initiated studies of the potential for biodegradation of the impounded wastewater. Batch tests indicated 30% of the COD was biodegradable within 48 hours after exposure to activated sludge from an industrial wastewater treatment plant. Chemical Oxygen Demand (COD) is a general indicator parameter which is proportional to the total priority pollutant organics in solution. The use of COD as an indicator parameter in environmental engineering wastewater treatability studies is accepted practice (Metcalf & Eddy, 1979). COD degradation rates are directly related to degradation rates of the organic compounds of concern. Based upon the apparent biodegradability of the wastewater, the TWQB developed permit restrictions which required SDS to follow a

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formal operating procedure and schedule for dewatering the pond. The pond wastewater was to be treated through approved "land irrigation methods" using the adjacent farmland owned by Mr. Sheridan.

From October through December, 1975, approximately 100,000 gallons of pond wastewater were applied to a 3-acre test plot to determine the feasibility of "land irrigation" as a disposal method for pond wastewater. The pilot study was conducted with the close cooperation of TWQB personnel. According to an interoffice TWQB memorandum dated February 5, 1976, the test results indicated an adverse impact upon vegetation. This was explained by TWQB personnel as resulting from elevated concentrations of inorganic salts in the soil, particularly chlorides. The TWQB concluded "land irrigation" was an effective treatment method for pond stormwater accumulations.

SDS began operating the evaporation system on May 17, 1976. The system was referred to as an "evaporation/rapid infiltration method of flood irrigation". From 1976 through 1984, more than 40 million gallons of wastewater were reportedly transferred from the pond to the evaporation system.

Table 3-8 presents a summary of available pond wastewater and soil leachate analytical data from the files of the TWQB and TDWR. The data indicate that the pond wastewater was moderately acidic, with elevated concentrations of dissolved inorganic salts, some heavy metals, and organics.

The TDWR did not make a detailed analysis of specific organic constituents.

The additional data in Table 3-8 are from laboratory soil leachate testing of the test plot and evaporation system areas collected by TDWR. The procedures for obtaining soil samples and conducting leachate tests were not standardized and the analytical results may not be directly comparable. The data indicate that, as the total amount of wastewater applied to the test plot increased, the soil leachate increased in acidity, total dissolved solids, and Total Organic Carbon (TOC) concentrations.

Table 3-9 presents an analysis of leachate from a "background" soil sample obtained by the TWQB from an unspecified location in the evaporation system area in November of 1976. Again, however, the leachability procedures for the test were not discussed in detail and the sample represents only one data point; therefore, these data may not be representative.

Resource Engineering analyzed a sample of the pond accumulated stormwater for priority pollutants by GC/MS techniques in June of 1984. The results of this analysis are presented in Table 3-10.

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Table 3-8

TWQB Evaporation System Analytical Data

(values in mg/l except pH which is in standard units)

Constituent	10/75 Pond Wastewater	9/76 Pond Wastewater	4/79 Pond Wastewater	Soil Leachate: 10/75 Background Soil	Soil Leachate: 11/6/75 Test Plot	Soil Leachate: 12/12/75 Test Plot	Soil Leachate: 6/21/76* "Landfarm"	Soil Leachate: 8/11/76* "Landfarm"	Soil Leachate: 8/30/76* "Landfarm"
pH	6.3-6.4	6.2	5.6	7.2	7.0	6.5	7.4	7.8	7.8
TDS	10,800-21,310	23,000	22,593	234	822	368	1,312	1,345	1,830
Cl-	4,400-4500	5,000	4,800	3.5	54	36	248	278	160
TOC	-	>6,400	7,900	18	32	75	183	393	183
COD	27,980-29,730	33,700	32,000						
Pb	0.12-0.60	0.088	0.21						
Zn	3.25-5.10	0.39	9.0						
Ni	0.25-0.50	0.19	1.24						
Cr	0.22-2.27	-	0.26						
Cu	1.26-2.99	0.23	1.17						
BOD		7,000							

*Arithmetic mean from the two sample points as reported by TDWR.

Table 3-9

TWQB Analytical Data on Background Soil Leachate

(Sampled 11/12/76)

Constituent	Concentration in Leachate (ug/l)
Cd	<10
Pb	<50
Ni	30
Zn	20
Ba	200
Cr	<20
Mg	100
Cu	10
Hg	0.55
Ca	70
Na	0.98

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Table 3-10

Pond Accumulated Stormwater

Priority Pollutant GC/MS Analysis

Compound	Concentration (ug/l)
Volatile Fraction:	
Benzene	BMDL (<500)
Ethylbenzene	BMDL (<500)
Tetrachloroethylene	510
Toluene	1610
Trichloroethylene	2910
Acid Fraction:	
2,4 Dimethylphenol	BMDL (<500)
Phenol	3550
Base Neutral Fraction:	
Isophorone	77
Naphthalene	BMDL (<50)
Phenanthrene	BMDL (<50)
Pesticide/PCB Fraction	None Detected

BMDL - Tentatively identified at concentrations below the method detection limits.

Note: These detection limits are greater than would be expected for distilled water samples due to interferences from other organic compounds.

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The data correspond well to what would be expected to be present from earlier sludge analysis. In addition to the priority pollutants in Table 3-10, a wide range of carboxylic acids were found, including: benzoic acid, toluic acid, butanoic acid, pentanoic acid and hexanoic acid. These compounds may be present as biodegradation products of the aromatic and aliphatic compounds found in the sludge.

Resource Engineering, Inc. conducted extensive sampling of the evaporation system in the spring of 1984 and winter of 1985. Figure 3-3 shows the sample locations of these investigations. Figure 3-4 shows the locations of water samples taken in July, 1984 to monitor water quality parameters during site remedial actions.

The results of pond and evaporation system water quality analyses are presented in Table 3-11. The overall decrease in oil and grease, TOC, phenolics, BOD, and COD levels as the wastewater retention time in the evaporation system increased indicates treatment was occurring. The total retention for the evaporation system was estimated at one month. Reductions in pollutant concentrations were occurring through successful on-site treatment mechanisms. The on-site treatment mechanisms consisted of primarily biodegradation, soil sorption and volatilization based on the physical properties and fate and transport characteristics of the organic compounds of concern (Section 3.2).

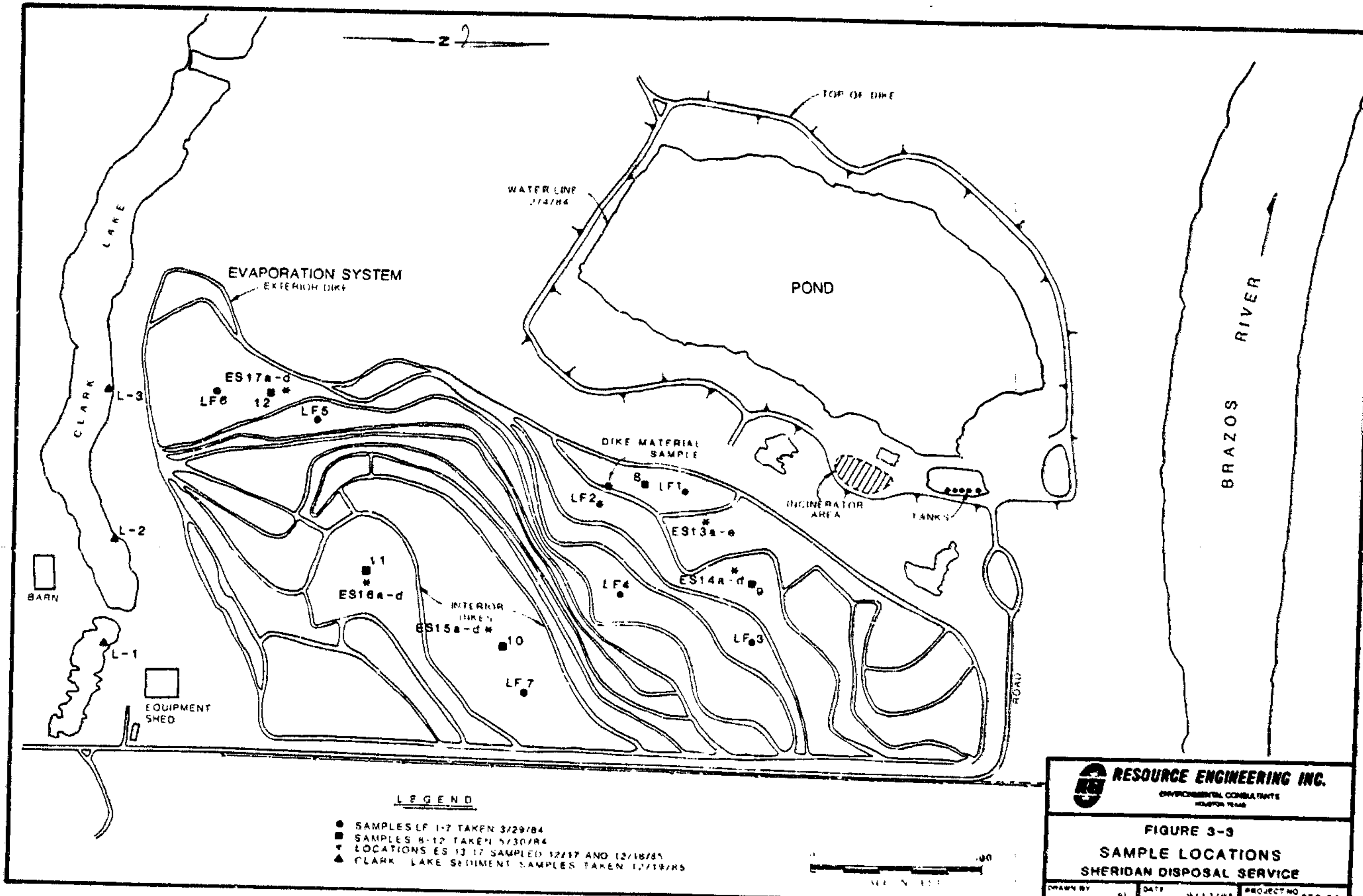

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FIGURE 3-3
SAMPLE LOCATIONS
SHERIDAN DISPOSAL SERVICE

DRAWN BY SL | DATE 9/12/85 | PROJECT NO 286 01

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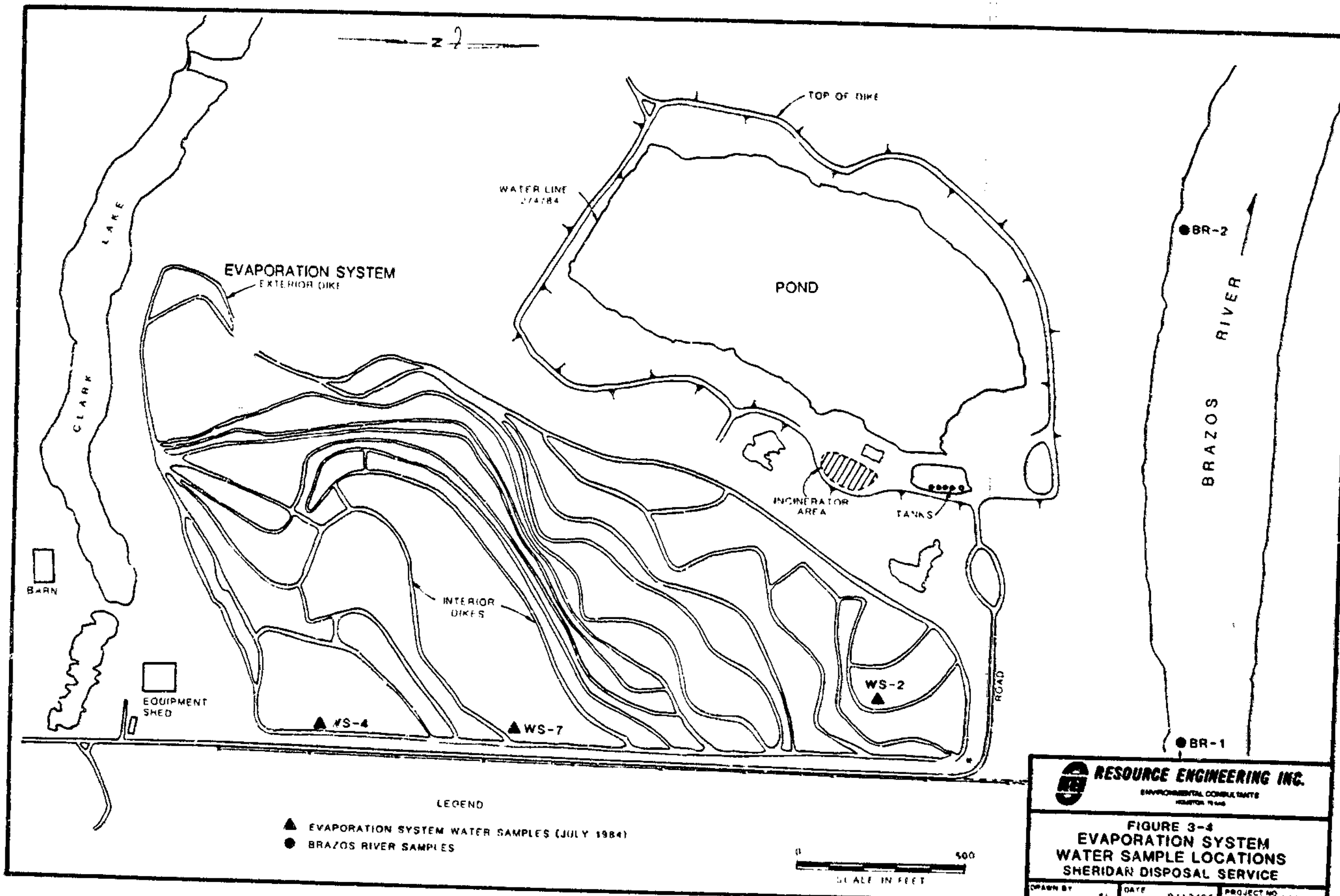

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FIGURE 3-4
EVAPORATION SYSTEM
WATER SAMPLE LOCATIONS
SHERIDAN DISPOSAL SERVICE

DRAWN BY	DATE	PROJECT NO
SS	9/12/85	288 01

Table 3-11

Pond and Evaporation System Water Quality

(REI data July, 1984)

Parameter (mg/l)*	Pond	Sample No. WS2 (Introduction)	WS7 (Mid-point)	WS4 (Final)
pH	5.4	6.9	7.4	7.6
Oil and Grease	640	129	125	74
TOC	7,130	2,958	1,413	1,180
Phenolics	13.84	5.12	1.06	0.92
COD	12,918	6,013	1,790	2,957
BOD	5,210	2,769	794	1,072
Cl^-	3,194	723	1,050	1,078
$SO_4^{=}$	<5	<5	<5	<5
TKN	85	430	72	134
TSS	768	780	1,777	528
As	<0.01	<0.01	<0.01	<0.01
Ba	<0.5	<0.5	<0.5	<0.5
Cu	0.20	0.02	0.04	0.03
Zn	1.07	0.02	0.03	0.01
Cr	0.28	<0.01	<0.01	<0.01
Cd	<0.01	<0.01	<0.01	<0.01
Hg	<0.005	<0.005	<0.005	<0.005
Ni	0.13	0.1	<0.01	<0.01
Ag	<0.01	<0.01	<0.01	0.11
Se	<0.01	<0.01	<0.01	<0.01

* pH given in standard units, all others in mg/l

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Heavy metals were found only in trace quantities just above detection limits and consisted of chromium, nickel and silver.

Table 3-12 presents an analysis of inorganic soil constituents for samples collected from the evaporation system and "background" locations by the EPA FIT team in July, 1983. Only the zinc level of the landfarm soil was found to be significantly above mean background concentrations. Total copper, nickel, and lead levels were within sampling and analytical variance ranges of the mean background values.

Table 3-13 summarizes the analytical results from the first set of near surface (0 to 18") soil samples obtained in March, 1984. Soil moisture, cation exchange capacity, and inorganic salt content are all important parameters in assessing the fate and transport of heavy metals in soil. The analytical data suggest that soil conditions (pH, and cation exchange capacity) favor the fixation and immobilization of heavy metals in the evaporation system. Soil metallic constituent fate and transport will be discussed further in Section 3.2.1.

The analyses indicate that PCBs are not present in the evaporation system soils, which is as expected because of the low solubility of PCBs in water (30 to 70 ppb); no PCBs were found in accumulated pond stormwater.

Table 3-12

EPA FIT Team Sampling Analysis July 1983

	Concentrations (ppm_w)			
Soil Constituent	Evaporation System Surface MF 0053	Evaporation System 4" Depth MF0054	Brazos River Upstream Sediments MF9697	Mean Ambient Background*
Aluminum	7,000	5,630	1320	33,000
Chromium	19	7	2	36
Barium	125	40	30	300
Beryllium	0.5	0.25	NA	0.6
Cobalt	6.67	2.5	NA	7
Copper	17.5	5	NA	14
Iron	1040	5870	1710	15,000
Nickel	20	8	NA	13
Manganese	241	183	83.2	290
Zinc	149	15.5	4.5	36
Boron	10	NA	NA	32
Vanadium	20	NA	NA	46
Arsenic	2	1	0.5	5.4
Selenium	0.2	NA	NA	0.39
Cadmium	0.15	NA	NA	<1
Lead	15	3	1	14
Ammonia	30	35	20	NA

NA - Not available

* Eastern United States average as referenced by EPA FIT Team.

Table 3-13
Evaporation System Soils Analysis
(March, 1984)

Constituent	LF#1	LF#2	LF#3	LF#4	LF#5	LF#6	LF#7	Dike Material
Heavy Metals:								
Arsenic (mg/kg)	(1.43)	(1.43)	(1.43)	(1.43)	(1.43)	(1.43)	(1.43)	(1.43)
Cadmium (mg/kg)	(1.43)	(1.43)	(1.43)	(1.43)	(1.43)	(1.43)	1.86	31.4
Chromium (mg/kg)	28.6	22.9	30.0	34.3	32.9	(1.43)	27.1	5.7
Copper (mg/kg)	32.9	31.4	32.8	32.8	37.1	22.9	27.1	41.4
Nickel (mg/kg)	(1.43)	2.86	11.4	7.14	(1.43)	(1.43)	(1.43)	(1.43)
Lead	103	55	70	66	68	62	62	121
Zinc	107	81	63	77	110	81	66	60
pH (Standard Units)	8.7	8.3	8.5	8.5	8.5	8.6	8.7	8.0
H_2O wt.%	33.8	32.7	23.2	27.7	31.5	24.9	36.4	47.0
Oil & Grease ppm	428	153	118	4,900	4,100	526	57	22,100
Phenol (mg/kg)	3.6	4.0	4.8	3.2	3.6	3.3	3.0	11.3
Total Kjeldahl Nitrogen (ppm/kg)	1,480	1,160	941	1,590	1,900	1,270	1,330	1,760
Sulfates (mg/kg)	855	230	532	674	987	867	568	664
Chlorides	835	1,223	1,012	1,019	1,221	1,095	971	184
Cation Exchange Capacity (meg/100 gm)	52.2	54.6	56.1	58.2	55.8	53.7	52.0	25.7
Sodium Absorption Ratio	2.62	2.48	2.63	2.95	3.53	3.00	3.06	1.47
PCB (mg/kg)	ND(<1)	NA	NA	NA	NA	ND(<1)	NA	ND(<1)

NA - Not Analyzed
ND - Not detected values in parentheses are detection limits
(1) All samples are composites from 0 to 18" depth
See Figure 3-3 for sample locations.

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Additional analytical results from samples obtained in May of 1984 are presented in Table 3-14. In July, 1985 the EPA requested an additional evaporation system evaluation. In response, the Sheridan Committee submitted in August and September of 1985, a Quality Assurance Project Plan and a Sampling and Analysis Plan for additional field activities. Samples were obtained from five locations in December 1985 to a minimum depth of three feet (Figure 3-3). Each sample was analyzed for oil and grease, nickel, chromium, lead, and zinc. A priority pollutant GC/MS analysis was performed on five samples as specified by the analysis plan. As required by the EPA, sampling locations for GC/MS analysis were the 3-foot depth at sampling locations nearest to prior samples #8, 10, and 12 and the worst case surface sample. The results of these analyses are presented in Tables 3-15 and 3-16.

The samples were obtained by hand augering and with a split core sampler. The equipment was decontaminated between each sampling event to prevent cross-contamination. A discussion of field sampling techniques and field records is

Table 3-14

Evaporation System Soil Analysis

(Resource Engineering Data May, 1984)

Sample Location	Depth (in)	Oil & Grease mg/kg)	Chromium mg/kg	Lead (mg/kg)	Zinc (mg/kg)
8	0-6	7,800	72	188	145
	6-12	3.000	54	81	57
9	0-6	7,200	64	60	103
	6-12	3,800	62	47	52
10	0-6	8,500	78	56	100
	6-12	2,700	53	48	46
11	0-6	6,600	50	21	81
	6-12	2,900	45	10	60
12	0-6	6,100	56	5	61
	6-12	3,400	60	7	55

See Figure 3-3 for sample locations.

Note - Oil and grease analytical results from May, 1984 and December, 1985 are not directly comparable since different analytical methods were used.

Table 3-15
Evaporation System Analysis

(Resource Engineering Data December, 1985)

Sample No.	Depth Zone (in)	Oil & Grease (mg/kg)	Nickel (mg/kg)	Chromium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Evaporation System Soil Samples:						
ES-13a	0-6	392,000	43.9	207.0	691.0	1,260
ES-13b	6-12	113,000	43.6	61.3	76.3	1,160
ES-13c	12-18	29,500	43.7	71.1	36.8	1,270
ES-13d	33-39	350	15.1	14.7	12.2	43.2
ES-13e	48-54	385	11.0	9.0	2.1	22.1
ES-14a	0-6	10,900	25.0	34.1	23.1	118
ES-14b	6-12	3,011	27.0	29.4	17.2	78.9
ES-14c	12-18	616	35.7	30.0	17.1	60.3
ES-14d	33-39	750	12.7	11.0	6.5	23.7
ES-15a	0-6	599	22.6	25.4	10.3	64.2
ES-15b	6-12	355	21.6	25.9	19.8	58.1
ES-15c	12-18	458	23.9	25.9	9.8	55.6
ES-15d	33-39	429	33.9	30.1	13.2	65.4
ES-16a	0-6	402	22.7	25.7	20.2	55.9
ES-16b	6-12	752	24.6	26.0	21.0	56.8
ES-16c	12-18	527	29.0	28.1	18.8	62.9
ES-16d	33-39	578	29.6	29.5	23.8	64.3
ES-17a	0-6	48,000	28.3	55.2	52.0	141
ES-17b	6-12	12,000	26.3	26.2	14.6	53.2
ES-17c	12-18	3,526	24.0	22.0	10.3	47.1
ES-17d	33-39	776	10.5	11.0	6.0	23.3
See Figure 3-3 for sample locations.						
Background Soil Samples:						
BS-1	0-6	2,004	15.5	56.1	22.1	56.0
BS-2	0-6	431	24.4	18.6	12.5	47.0
BS-3a	0-6	279	12.8	6.1	<1.0	22.3
BS-3b	6-12	228	9.8	11.7	8.3	23.1

See Figure 3-5 for sample locations.

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Table 3-16
Evaporation System Soils Priority Pollutant GC/MS Analysis
(Resource Engineering Data December, 1985)

Compound (Units are mg/kg)	13A (0-6" Depth)	13D (33-39" Depth)	15D (33-37" Depth)	17D (33-39")	S123 Background Soil Composite
Volatile Fraction:					
Benzene	67.9	ND	ND	ND	ND
Ethylbenzene	579	ND	ND	ND	ND
Methylene chloride	ND	BMDL (<.014)	0.060	0.221	ND
Tetrachloroethylene	43.5	ND	ND	ND	ND
Toluene	263	ND	ND	ND	ND
Acid Fraction: (ug/kg)					
Benzoic acid[1]	ND	ND	ND	BMDL (<0.330)	ND
2-4 Dimethyl phenol	494	ND	ND	ND	ND
Phenol	1,470	0.236	ND	ND	ND
Base/Neutral Fraction:					
Anthracene	ND[2]	BMDL (<0.063)	ND	ND	ND
Benzyl alcohol[1]	ND[2]	BMDL (<0.330)	BMDL (<0.330)	BMDL (<0.330)	BMDL (<0.330)
Dimethyl phthalate	ND[2]	BMDL (<0.330)	ND	ND	ND
Di-N-butyl phthalate	ND[2]	BMDL (<0.330)	ND	ND	ND
Di-N-octyl phtlalate	ND	ND	ND	ND	0.451
Fluoranthene	ND[2]	BMDL (<0.073)	ND	ND	ND
Naphthalene	ND[2]	ND	ND	ND	0.135
N-Nitrosodiphenylamine	ND[2]	0.075	ND	ND	ND
Pesticides/PCB Fraction:	ND	ND	ND	ND	ND

See Figure 3-3 for sample locations.

1 Benzoic acid and benzyl alcohol are non-priority pollutant compounds which were specifically quantified due to their being common degradation products of aromatics

2 Method detection limits were high due to sample matrix interferences

ND - Not detected

BMDL tentatively identified at concentrations below method detection limits

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contained in Section 4.0 of the Sampling and Analysis Plan in Appendix 3C.

Soil samples utilized to determine site background levels of trace elements and organics were collected at three locations as specified by the EPA. These locations included two samples from the adjoining property to the east of the Sheridan site and one sample from Sheridan property, west of the pond. Figure 3-5 shows the locations of the background samples and Table 3-15 presents the analytical results.

As Table 3-15 indicates, sample BS-1 had significantly higher oil and grease and chromium levels than the other background samples. Aerial photography from 1984 indicates that BS-1 may have been collected in the area of a former crude oil reserve pit which may make the sample unsuitable as a background sample. GC/MS analysis of a composite of soil background samples detected naphthalene and Di-n-Octyl phthalate which are compounds present in crude oils. Table 3-17 is a comparison of background mean values calculated with and without sample BS-1 data. Table 3-17 data indicate that BS-1 should not be considered a valid background sample because of the large increase in confidence limits caused by its inclusion in the statistical base.

The existing database of three background samples is not large enough to adequately define background. The large statistical confidence limits on background concentration levels in Table 3-17 will most likely decrease

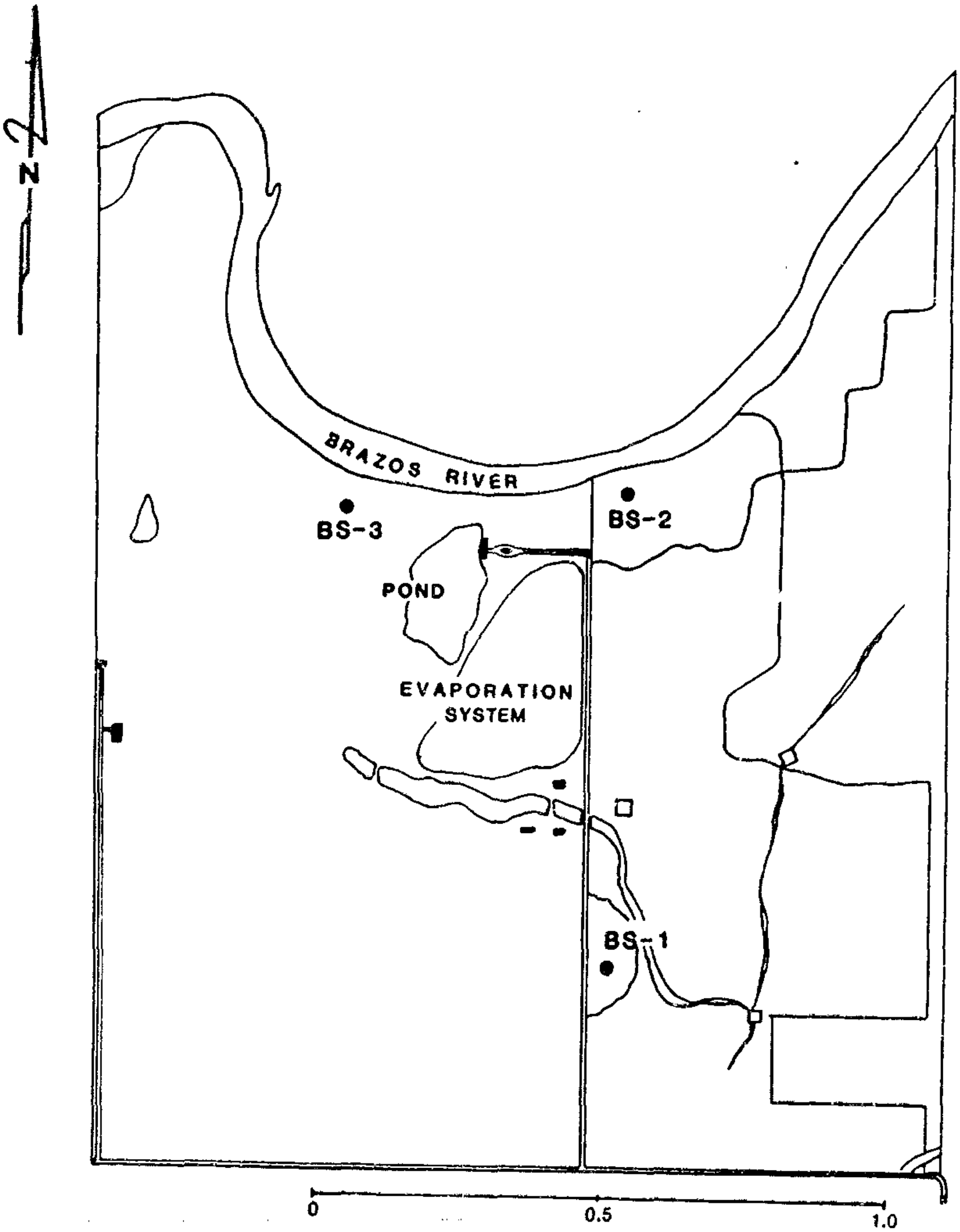

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FIGURE 3-5
BACKGROUND
SOIL SAMPLE LOCATIONS
SHERIDAN DISPOSAL SERVICE

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when additional background sample data becomes available. Additional soil sampling will further define background conditions.

Table 3-17

Mean Background Soil Trace Metals and Organics

(values in mg/kg)

O&G	Nickel	Chromium	Lead	Zinc
BS-1,2,3a,3b:				
736 ± 2363	15.6 ± 17.5	23.1 ± 62.7	11.0 ± 24.5	37.1 ± 47.4
BS-2,3a,3b:				
313 ± 335	15.7 ± 24.5	12.1 ± 19.9	7.3 ± 18.5	30.8 ± 44.6

95% Confidence Limits are based on t values corrected for sample size and the sample standard deviation

For n=4 95% Confidence Limits = 2.78 x Sample Standard Deviation
For n=3 95% Confidence Limits = 3.18 x Sample Standard Deviation

Table 3-18 summarizes the results of evaporation system sampling in comparison to these site-specific, background concentration levels. As discussed later, only sample pt. #13 was found to have metal concentration levels approaching phytotoxic limits.

As requested by the EPA, log-normal plots (Figures 3-6 through 3-15) were made of the concentration profiles of indicator parameters at each sample location. Log

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Table 3-18

Summary of Evaporation System Analytical Results

(Resource Engineering, Inc. Data December, 1985)

Indicator Parameter	Maximum Depth of Elevated Concentrations Above Preliminary Site Background				
	ES13	ES14	ES15	ES16	ES17
Oil & Grease	2.75 ft.	1.25	-	1.0	~3.5
Nickel	2.5 ft.	-	-	-	-
Chromium	2.5 ft.	0.5	-	-	0.5
Lead	2.5 ft.	-	-	-	0.5
Zinc	2.5 ft.	1.25	-	-	0.5

- Within Site Specific Background Concentrations

Note: Site Specific Background Concentrations are preliminary. Additional sampling planned for the Evaporative System includes five additional background samples. This additional information may revise the values in this table.

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concentration profiles in Figure 3-6 through 3-15 define sample point specific background levels. Contaminant concentrations decrease exponentially with distance away from a point source. The slope of log concentration vs. depth should be linear and is as shown by Figures 3-6 through 3-15. If the slope of log concentration vs depth approaches zero as background levels are reached, then horizontal lines represent background concentrations. If the plotted values do not approach zero slope, a comparison of the end points to the preliminary background sample levels may be used to determine where these concentrations are at background levels. The extrapolated point at which the slope goes to zero represents the maximum depth of contaminant migration.

Location 13 (Figures 3-6 and 3-7) was chosen as a worst-case sampling point in the evaporation system, since it is located in the inlet cell to which pond wastewater was pumped to initiate evaporation. The upper two feet at this location is a heavy, organic, weathered sludge. The upper six inches of this sludge was analyzed by GC/MS for organics and the results are presented in Table 3-16. The presence of benzene, ethylbenzene, tetrachloroethylene, toluene, 2,4-dimethylphenol and phenol all identify this sludge as originating in the pond.

Figure 3-6 indicates oil and grease levels are above background to a depth of 2.75 feet at location 13. The

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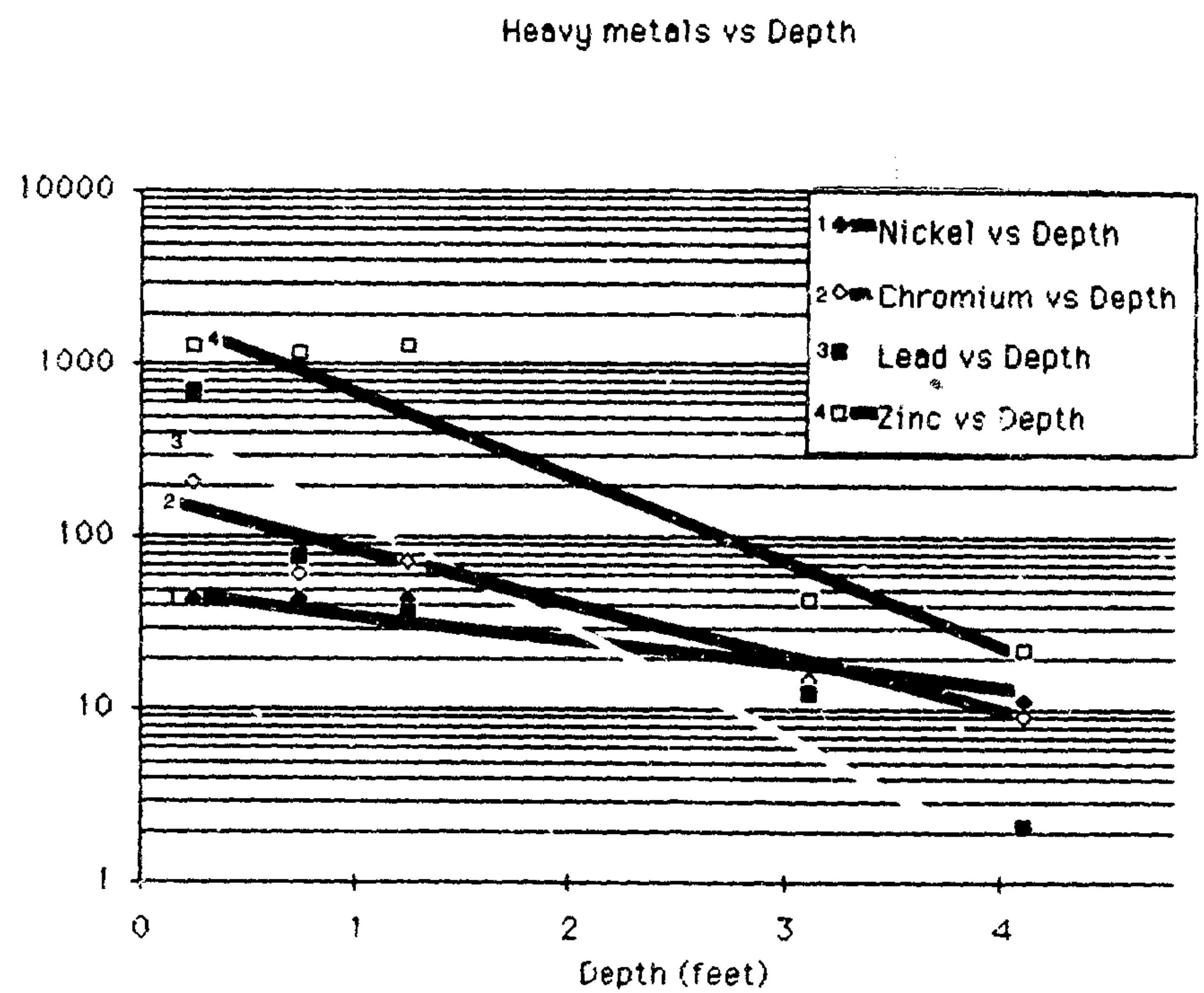

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FIGURE 3-7
EVAPORATION SYSTEM
SAMPLE PT#13
HEAVY METALS VS DEPTH
SHERIDAN DISPOSAL SERVICE

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figure shows an excellent straight-line correlation of log oil and grease values when plotted versus depth.

Figure 3-7, a log plot of heavy metals versus depth, is consistent with Figure 3-6 and indicates that heavy metals reach background levels at approximately 2.5 feet below grade. GC/MS analysis of the sample at a 3 foot depth found 0.24 mg/kg phenol present and trace levels of base/neutral fraction compounds which means it is essentially non-contaminated.

Figures 3-8 and 3-9 plot the indicator parameter's log concentration versus depth for sample location 14. Sample location 14 is approximately 200 feet northeast of location 13 as indicated by Figure 3-3. This location is a high point in a cell containing one to six inches of standing water. No surface sludge contamination is visible and the soil is a moist, brown clay. Oil and grease is above background to a depth of approximately 1.25 feet, while all of the heavy metals are within analytical error limits of preliminary background levels except for zinc which parallels the distribution of oil and grease values to the same depth of 1.25 feet.

Figures 3-10 through 3-13 plot the indicator parameter distributions for sample locations 15 and 16. Sample locations 15 and 16 are both in interior cells in the south-central portion of the evaporation system. The soil type in both locations is a moist, dark, red-brown clay with numerous plant roots in the upper 1 foot section. The data indicate

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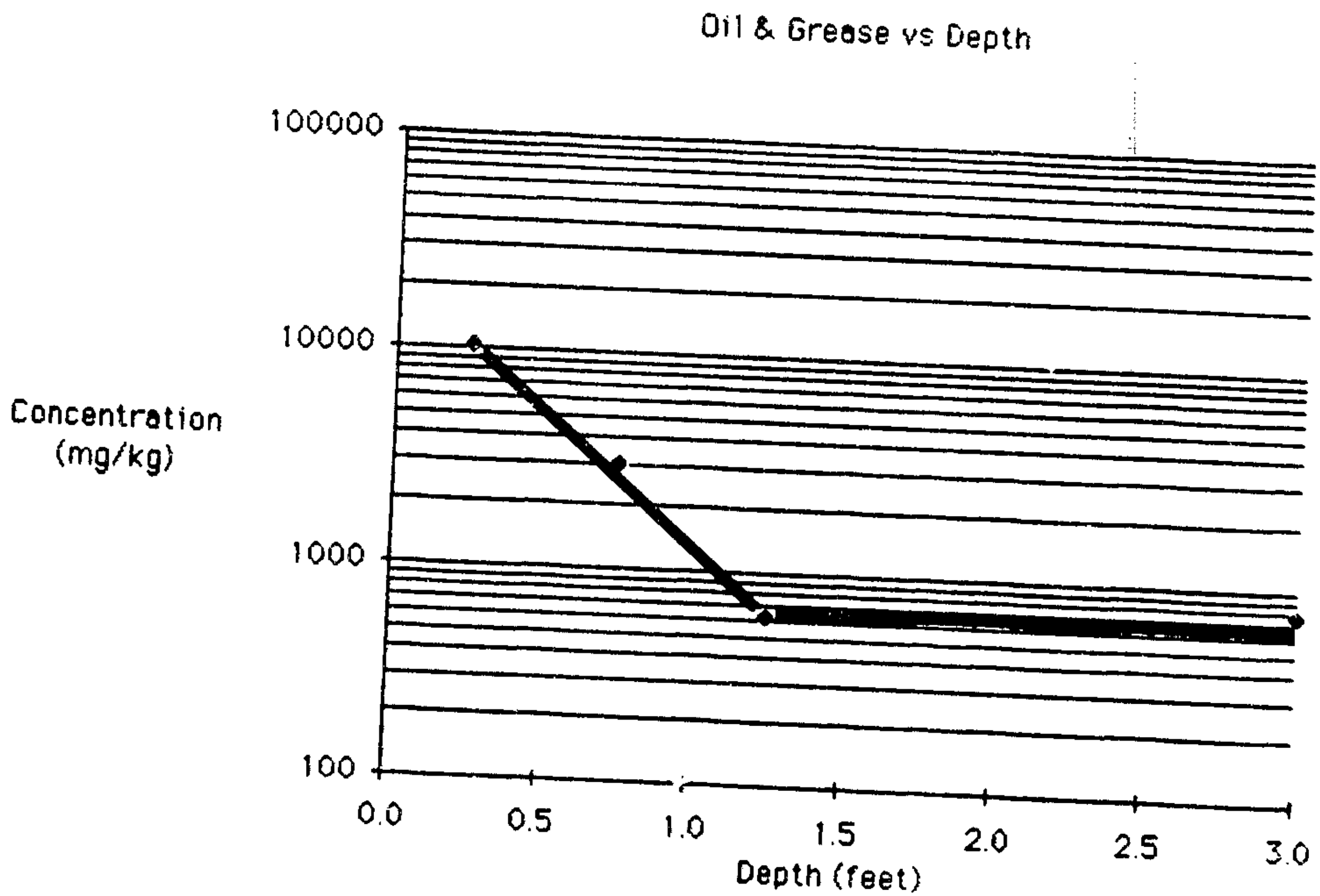

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FIGURE 3-8
EVAPORATION SYSTEM
SAMPLE PT#14
OIL & GREASE VS DEPTH
SHERIDAN DISPOSAL SERVICE

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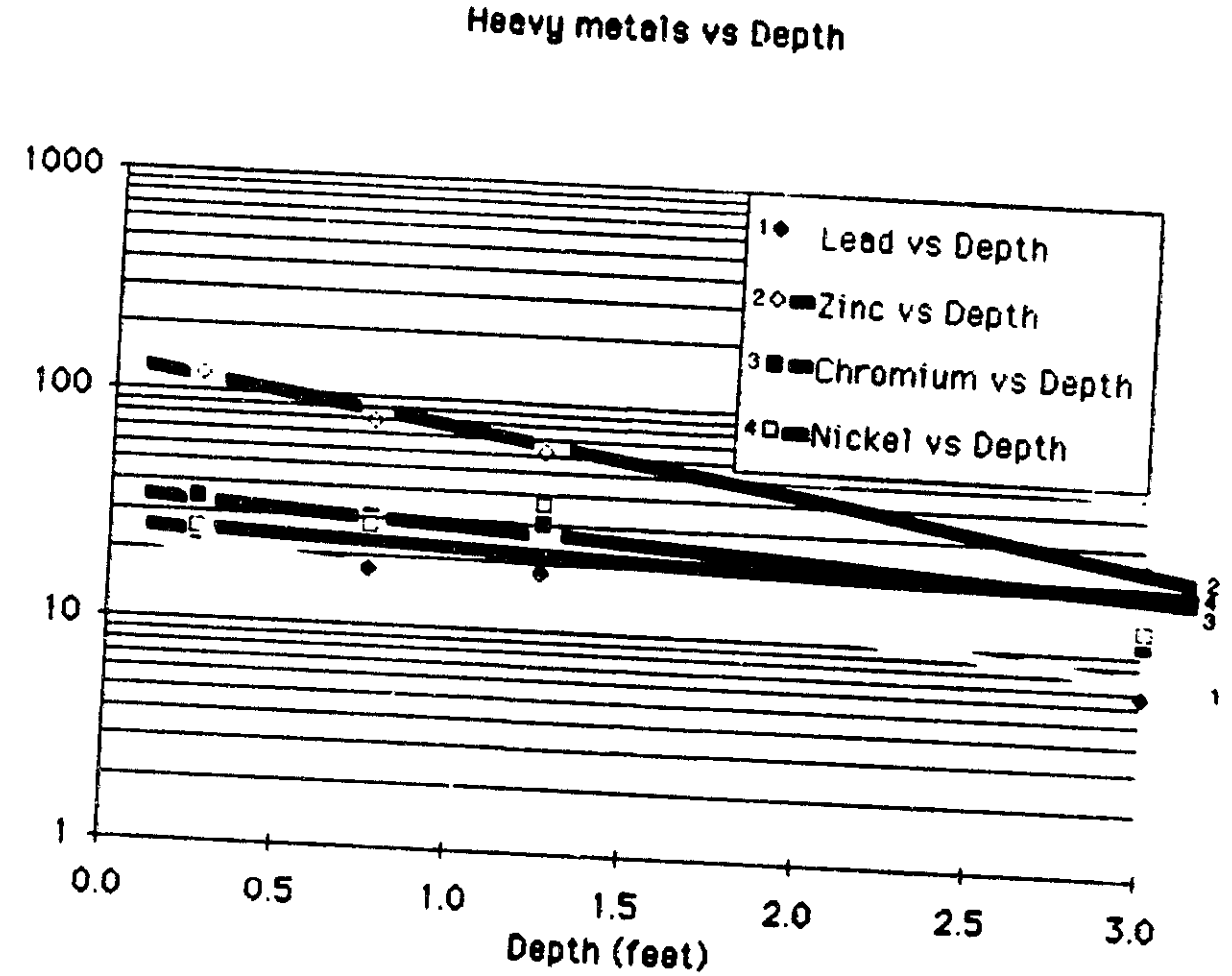

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FIGURE 3-9

EVAPORATION SYSTEM

SAMPLE PT. #14

HEAVY METALS VS DEPTH

SHERIDAN DISPOSAL SERVICE

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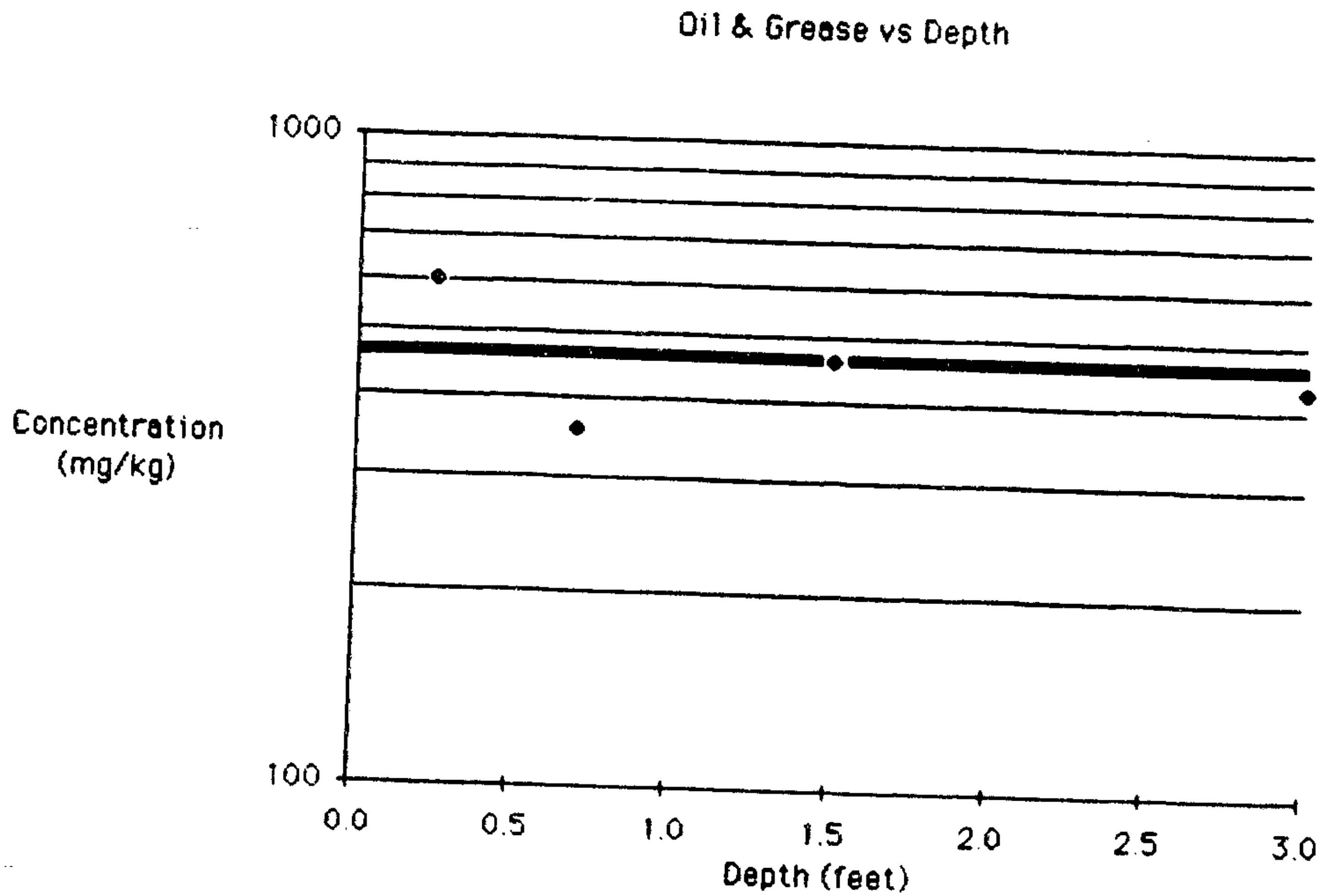

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FIGURE 3-10
EVAPORATION SYSTEM
SAMPLE PT #15
OIL & GREASE VS DEPTH
SHERIDAN DISPOSAL SERVICE

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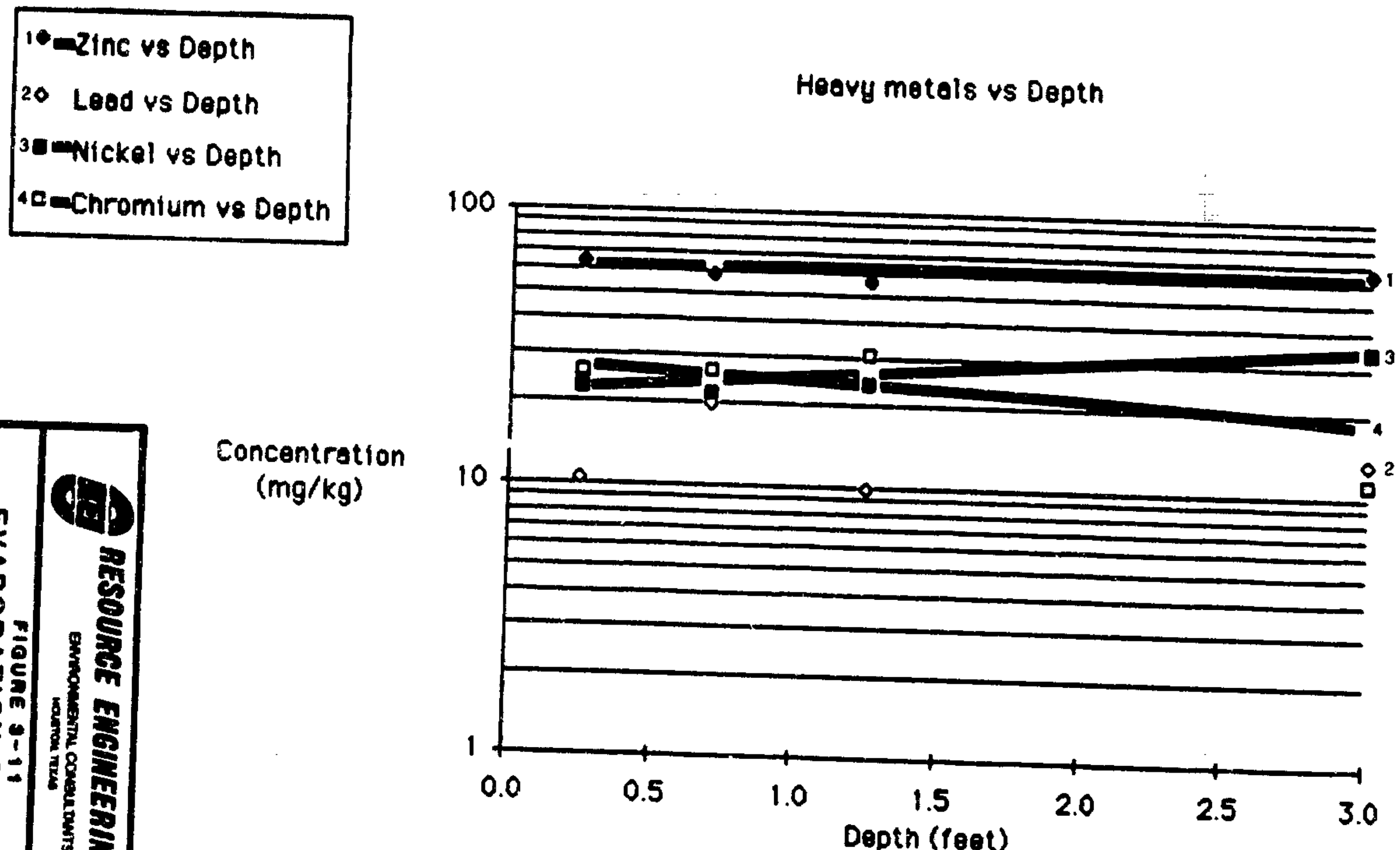

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FIGURE 3-11
EVAPORATION SYSTEM
SAMPLE PT. #15
HEAVY METALS VS DEPTH
SHERIDAN DISPOSAL SERVICE

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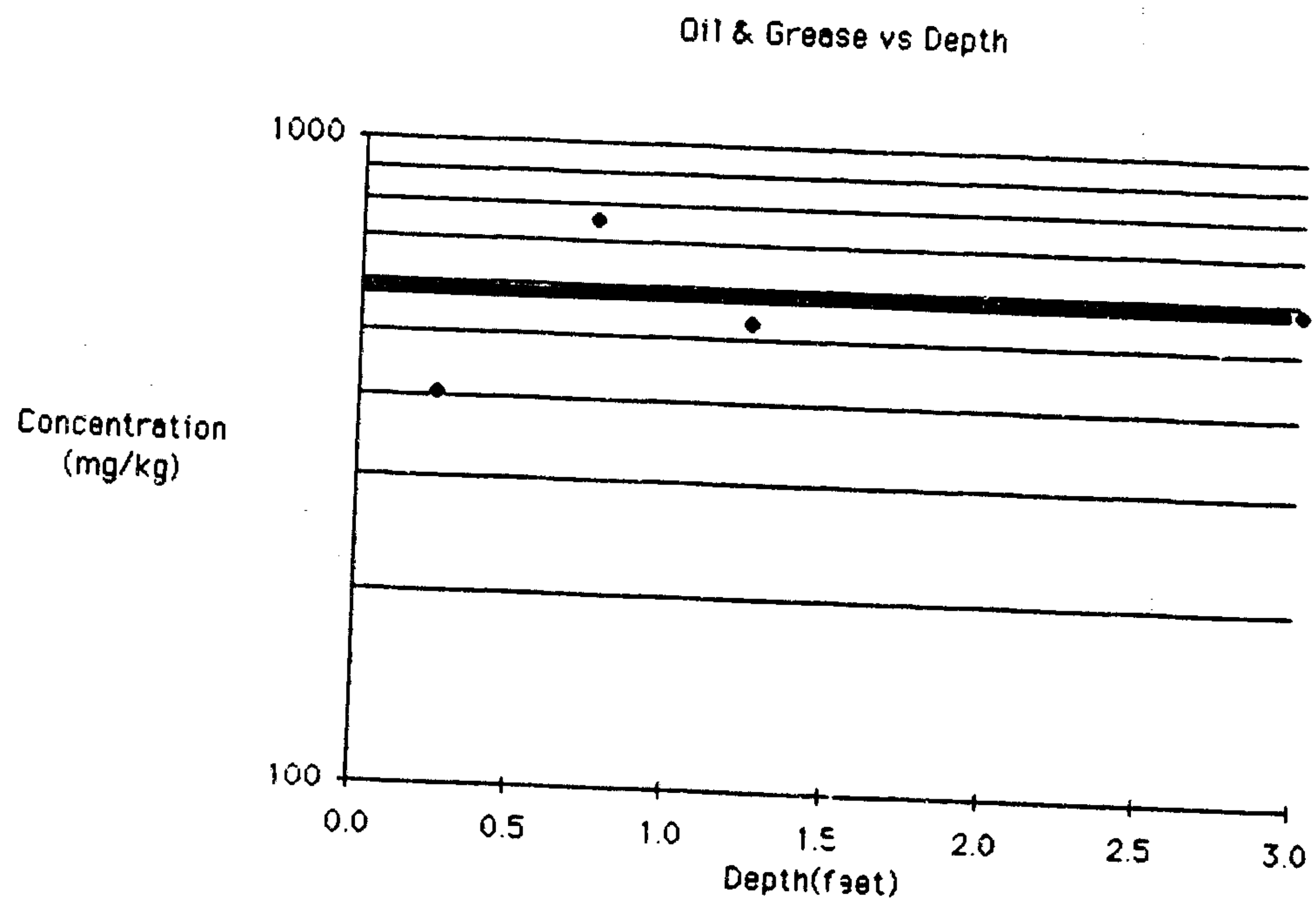

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FIGURE 3-12
EVAPORATION SYSTEM
SAMPLE PT#16
OIL & GREASE VS DEPTH
SHERIDAN DISPOSAL SERVICE

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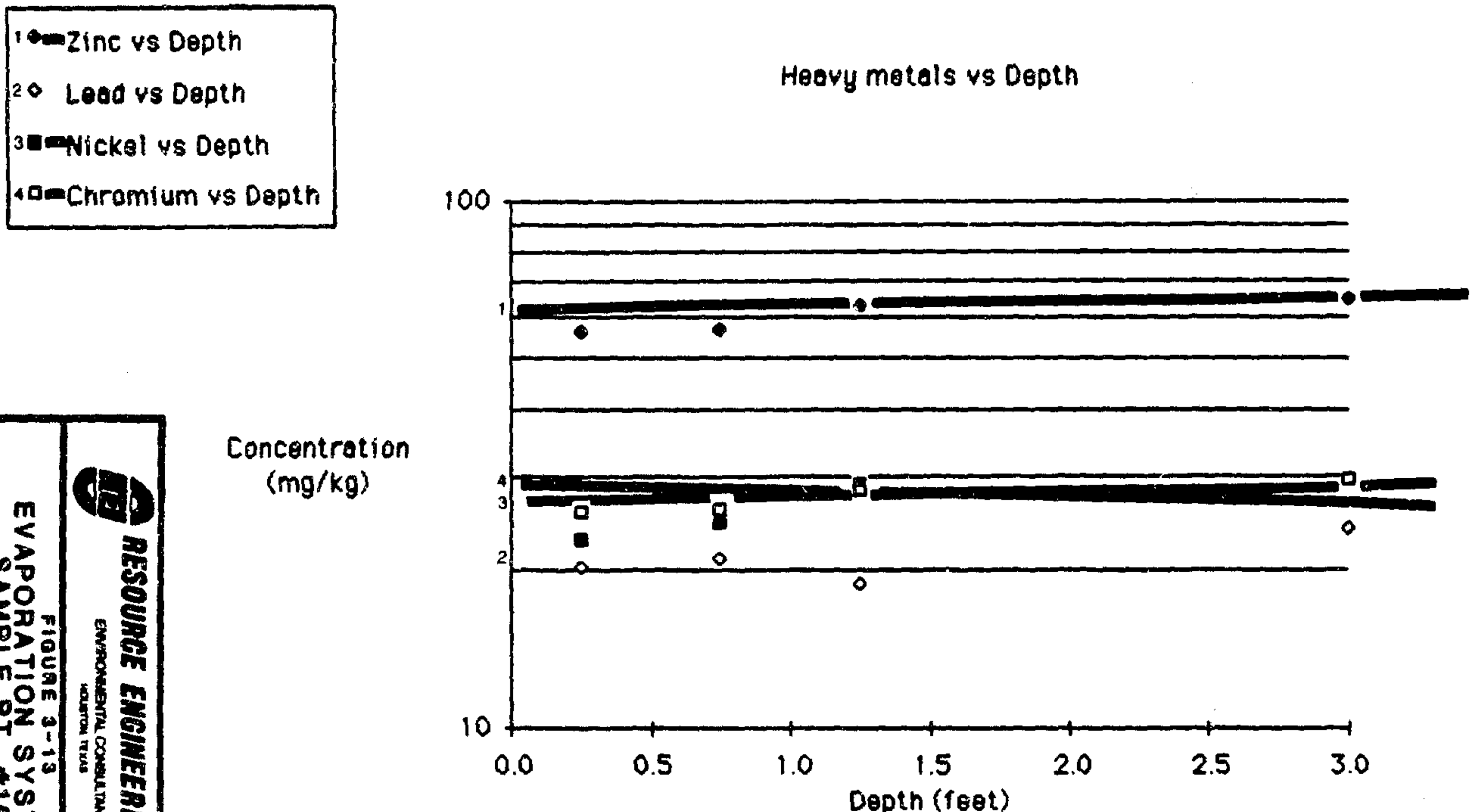

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FIGURE 3-13
EVAPORATION SYSTEM
SAMPLE PT. #16
HEAVY METALS VS DEPTH
SHERIDAN DISPOSAL SERVICE

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that these two locations are within analytical error limits of preliminary estimates of background. Analytical errors include imprecision in laboratory analyses and background characterization. Error limits are defined as 95% level confidence limits corrected for the degrees of freedom in the sample size. GC/MS analysis of the three-foot depth sample at location 15 confirms there are no priority pollutant organic contaminants present.

Figures 3-14 and 3-15 show the results of analyses at sample location 17. Sample location 17 is in the southwest corner of the evaporation system as shown on Figure 3-3. The soil was observed to be a dark, moist silt. Oil and grease is present at elevated concentrations to a depth greater than 3.0 feet (approximately 3.5 feet by extrapolation). Chromium, lead, and zinc are present at elevated levels in the first six inches of topsoil. GC/MS analysis of the 3-foot level detected only trace concentrations of aromatic degradation compounds (benzyl alcohol and benzoic acid). After a review of analytical QA/QC data, the methylene chloride levels in several GC/MS results were considered laboratory background. Figure 3-16 is an illustration of sampling procedures used in obtaining evaporation system soil samples.

The evaporation system cells characterized by 15 sample points have no significantly elevated concentrations of either heavy metals or organics. As would be expected, the majority of contamination is near the point of introduction of

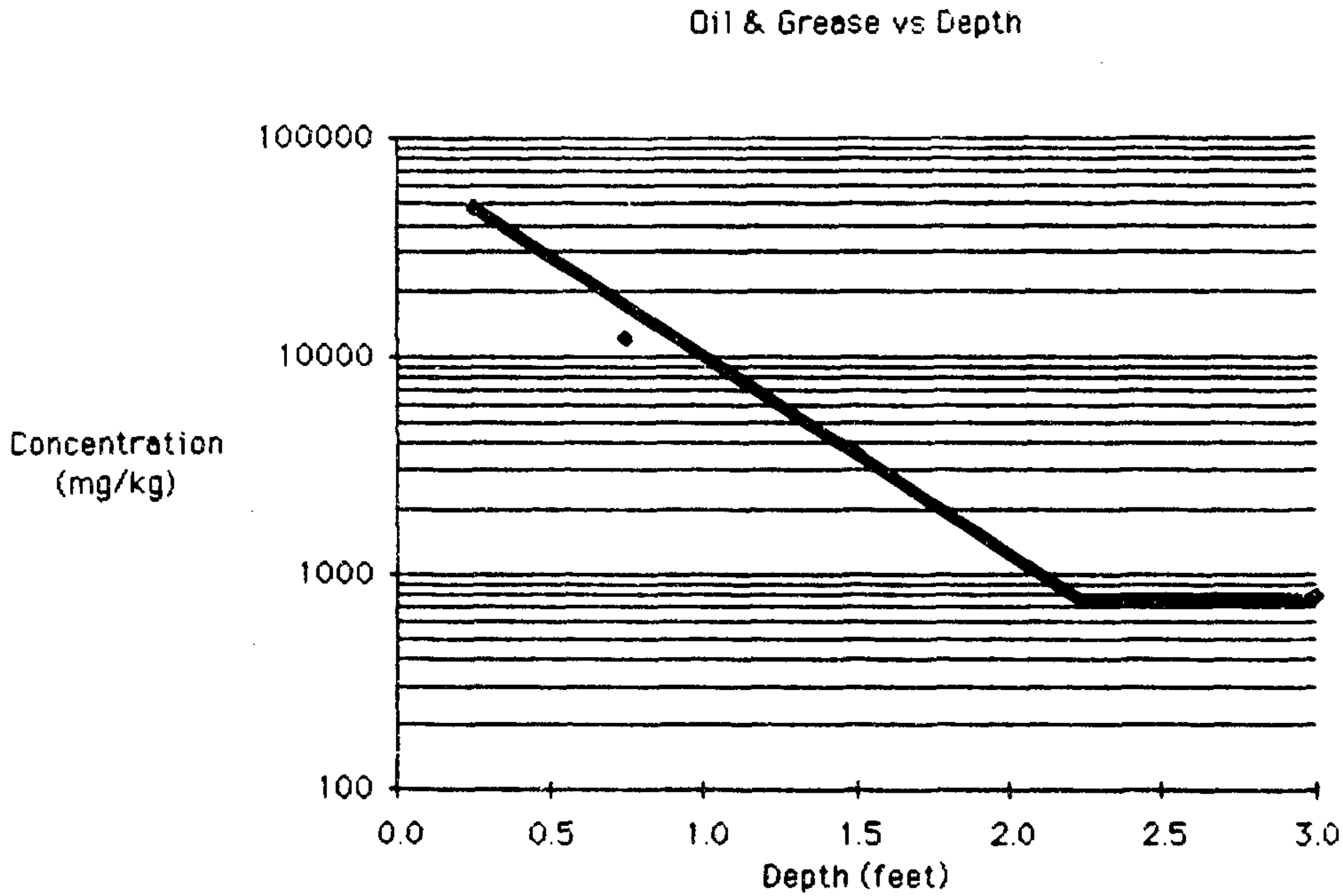

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FIGURE 3-14
EVAPORATION SYSTEM
SAMPLE PT#17
OIL & GREASE VS DEPTH
SHERIDAN DISPOSAL SERVICE

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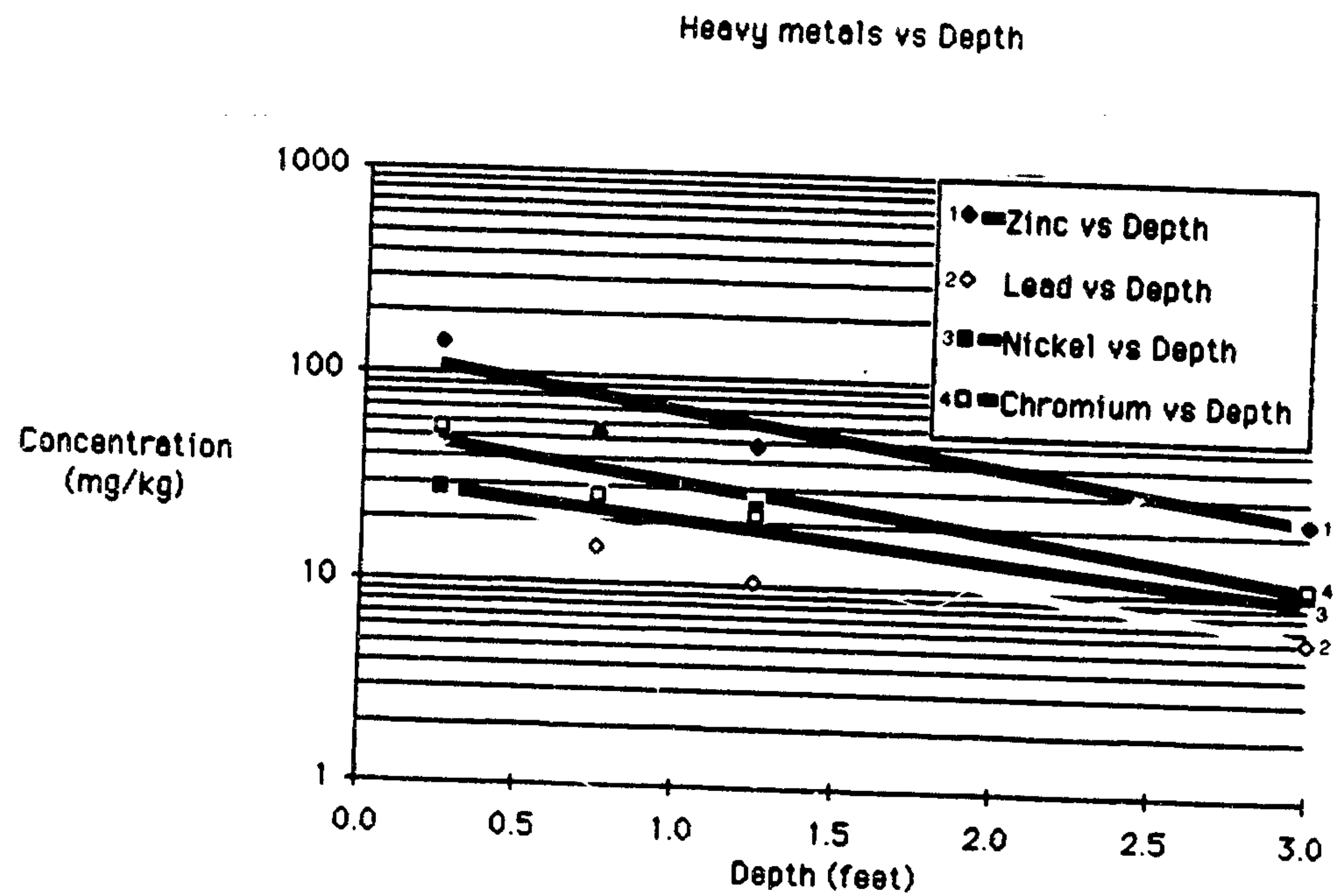

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FIGURE 3-16

EVAPORATION SYSTEM
SAMPLE PT. #17
HEAVY METALS VS DEPTH
SHERIDAN DISPOSAL SERVICE

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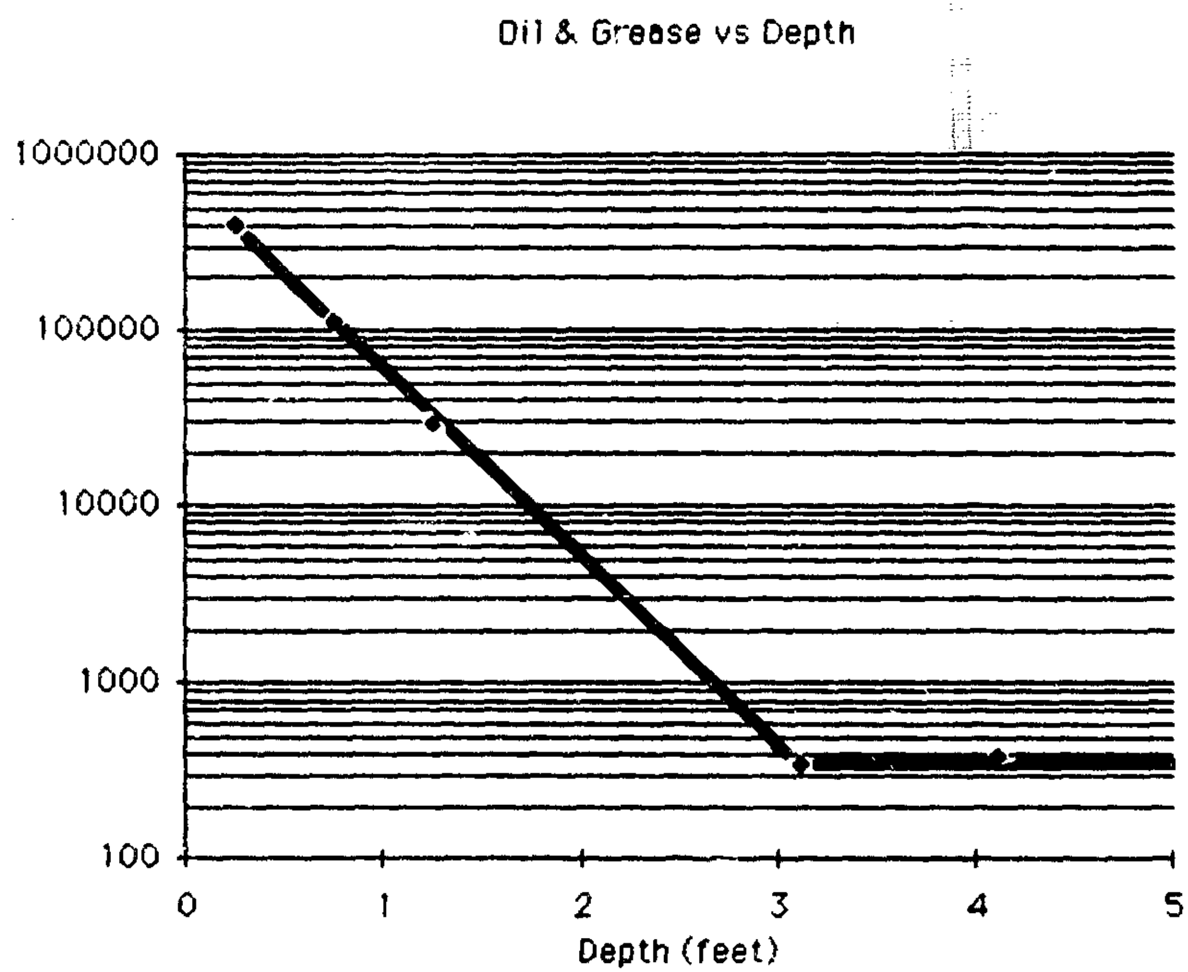

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FIGURE 3-8
EVAPORATION SYSTEM
SAMPLE PT#13
OIL & GREASE VS DEPTH
SHERIDAN DISPOSAL SERVICE

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EVAPORATION SYSTEM SAMPLE PT # 13
HAND AUGERING AND COLLECTION OF CUTTINGS

EVAPORATION SYSTEM SAMPLE PT. #13
FACING SOUTHEAST

REMOVAL OF SHELBY TUBE SAMPLER

REMOVAL OF INTACT CORE SAMPLE

EQUIPMENT DECONTAMINATION

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FIGURE 3-16
EVAPORATION SYSTEM
SOIL SAMPLING
SHERIDAN DISPOSAL SERVICE

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pond stormwater. The cells closest to the pond wastewater inlet contain contaminants above background concentrations at depths of up to 3.5 feet below grade. These levels are primarily in surface sludges which were pumped along with pond stormwater into the evaporation system and remained in the inlet cell. Additional sampling of the evaporation system is planned in the Spring of 1987.

Based on the data available, oil and grease and total zinc appear to be the most sensitive indicator parameters. Oil and grease (O&G) levels are a general indicator of priority pollutant organic contamination as indicated by a comparison of Tables 3-15 and 3-16. Sampling in the Summer of 1987 will further define this relationship. Zinc is the most mobile heavy metal of concern as discussed later in the fate and transport section (p 3-63) and as shown by the slope of zinc migration at sample points ES13 and ES17. Zinc has the highest concentration of any heavy metal of concern as shown in Table 3-2. Other heavy metals of concern were never detected at elevated levels without zinc also being elevated. For these reasons zinc and oil and grease are appropriate indicator parameters of site contamination.

Table 3-19 compares typical background levels, phytotoxic levels, and maximum in-place closure concentration levels which have been used in closure of RCRA land treatment units. Except for the obvious sludge directly at the inlet to the evaporation system, none of the samples had heavy metal

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Table 3-19

Heavy Metal Remedial Concentration Levels

(mg/kg)

	Evaporation System Range	Preliminary Site Background	Common Background Range[1]	Phytotoxic Levels[2]	EPA Maximum Metal Concentrations For In-Place Closure of Hazardous Waste Land Treatment Unit[1]
Chromium	<1.4 - 204	12.1 ± 19.9	1 - 1,000	75 - 100	1,000
Lead	5 - 691	7.3 ± 18.5	2 - 200	100 - 400	1,000
Nickel	<1.4 - 44	15.7 ± 24.5	5 - 500	100	100
Zinc	22 - 1260	30.8 ± 44.6	10 - 300	70 - 400	500

1 Source: Hazardous Waste Land Treatment; USEPA, Office of Solid Waste and Emergency Response, SW-874, April 1983

2 Source: Pendias, A.K, and Pendias S.H.; Trace Elements in Soils and Plants; CRC Press, 1984

concentrations in excess of typical background levels. Additionally, in all cases except for the inlet cell sludge, heavy metal concentrations were below average excessive phytotoxic levels (Table 3-19).

Table 3-20 is a summary of the technical literature estimating concentrations of trace elements considered phytotoxic in soils. The values vary considerably because phytotoxicity is dependent on the soil type and specific plant species.

3.1.4 <u>Test Plot Area</u> - The three-acre test plot was used from October through December of 1975 to study the feasibility of "land irrigation" as a disposal method for pond wastewater. The site was located north and slightly west of the pond in a former truck garden. 003506

Only 100,000 gallons of wastewater were applied to this plot; the presence of soil contaminants was never determined. Considering that the wastewater loading rate on the test plot was at least an order of magnitude less than the evaporation system area, no significant contamination would be expected. To investigate this hypothesis, samples were taken in December, 1985 at three locations in the test plot area. Two of the samples were taken from 0 to 6-inch depths and the third location was sampled at both the surface and at a depth of 6 to 12 inches. The samples were analyzed for total metal concentrations of lead, zinc, nickel and chromium as indicators of possible contamination. Table 3-21 presents the results of these analyses.

Table 3-20

Concentrations of Trace Elements Considered Phytotoxic In Soils (PPM DW)

Element	a	b	c	d	e	f	Average
	Concentrations as given by various authors						
Ag	-	-	2	-	-	-	2
As	-	50	25	30	20	15	28
B	30	100	-	100	25	-	64
Be	-	10	-	10	10	-	10
Br	-	-	-	20	10	-	15
Cd	-	5	8	5	3	-	5
Co	30	50	25	50	50	50	43
Cr	-	100	75	100	100	-	94
Cu	60	100	100	100	100	125	98
F	-	500	-	1000	200	-	567
Hg	-	5	0.3	5	2	-	3
Mn	3000	-	1500	-	-	-	2250
Mo	4	10	2	10	5	-	6
Ni	-	100	100	100	100	100	100
Pb	-	100	200	100	100	400	180
Sb	-	-	-	10	5	-	8
Se	-	10	5	10	10	-	9
Sn	-	-	-	50	50	-	50
Tl	-	-	-	-	1	-	1
V	-	-	60	100	50	-	70
Zn	70	300	400	300	300	250	270

a) Kovalskiy V.V. "Geotechnical Environment, Health and Diseases" in Trace Subst. Environ. Health Vol 8, Hemphill, 1974

003507

Table 3-20 (continued)

b) El-Bassam, N and Tietjen C. "Municipal Sludge as Organic Fertilizer with Special Reference to the Heavy Metal Constituents" in Soil Organic Matter Studies Vol. 2, IAEA Vienna 1977

c) Linzon S. N. "Phytoxicology Excessive Levels for Contaminants in Soil and Vegetation" report of ministry of the environment, Ontario, Canada, 1978

d) Fabata-Pendias A. "Current Problems in Chemical Degradation of Soils" presented at Conf. on Soil and Plant Analysis in Environmental Protection, Falenty/Warsaw, October 29, 1977

e) Klofe A. "Content of Arsenic; Cadmium, Citromium, Fluorine, Lead, Mercury and Nickel in Plants grown on Contaminated Soil", UN-ECE Simp. on Effects or Air-Born Pollution on Vegetation, Warsaw, August 20, 1979

f) Kitagashi, R. and Yamane F. Eds, Heavy Metal Pollution in Soils of Japan, Japan Science Society Pres, Tokyo, 1981

Table 3-21

Test Plot Trace Element Analysis; December, 1985

Sample #	Depth (inches)	Chromium (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)
TP-1a	0-6	11.5	8.68	7.70	80.0
TP-1b	6-12	9.90	7.90	7.6	26.4
TP-2	0-6	6.70	1.30	10.5	19.7
TP-3	0-6	8.20	<1.0	12.4	20.8
Site Background*					
BS-2	0-6	18.6	12.5	24.4	47.0
BS-3a	0-6	6.1	<1.0	12.8	22.3
BS-3b	6-12	11.7	8.3	9.8	23.1

*See Figure 3-17 for sample locations.

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All values are within the calculated background concentration ranges except for a single, slightly elevated concentration of zinc in sample TP-1a. No areas of organic contamination were found in the evaporation system that did not also have elevated concentrations of heavy metals. Since both systems treated accumulated pond stormwater, heavy metals are an adequate indicator for potential contamination. The analytical results confirm that the area has no significant contamination.

Besides the test plot area, the road network north of the pond and the main entrance was surveyed. Soil samples were taken in areas where spills may have occurred. Figure 3-17 shows the sample locations and Table 3-22 presents the indicator parameter results. Sample C-6 was taken from weathered sludge (before cleanup) approximately 15 feet in diameter on the bank of the Brazos River north of the pond. As expected, the sample continued to have high concentrations of oil and grease and zinc. As part of site management activities, the Sheridan Committee removed approximately 11 cubic yards of this material to the interior slope of the pond levee. Samples C-10 and C-11 of remaining soils after cleanup indicate removal of visual sludges was adequate. No other sample location but location C-7 indicated any potentially contaminated areas.

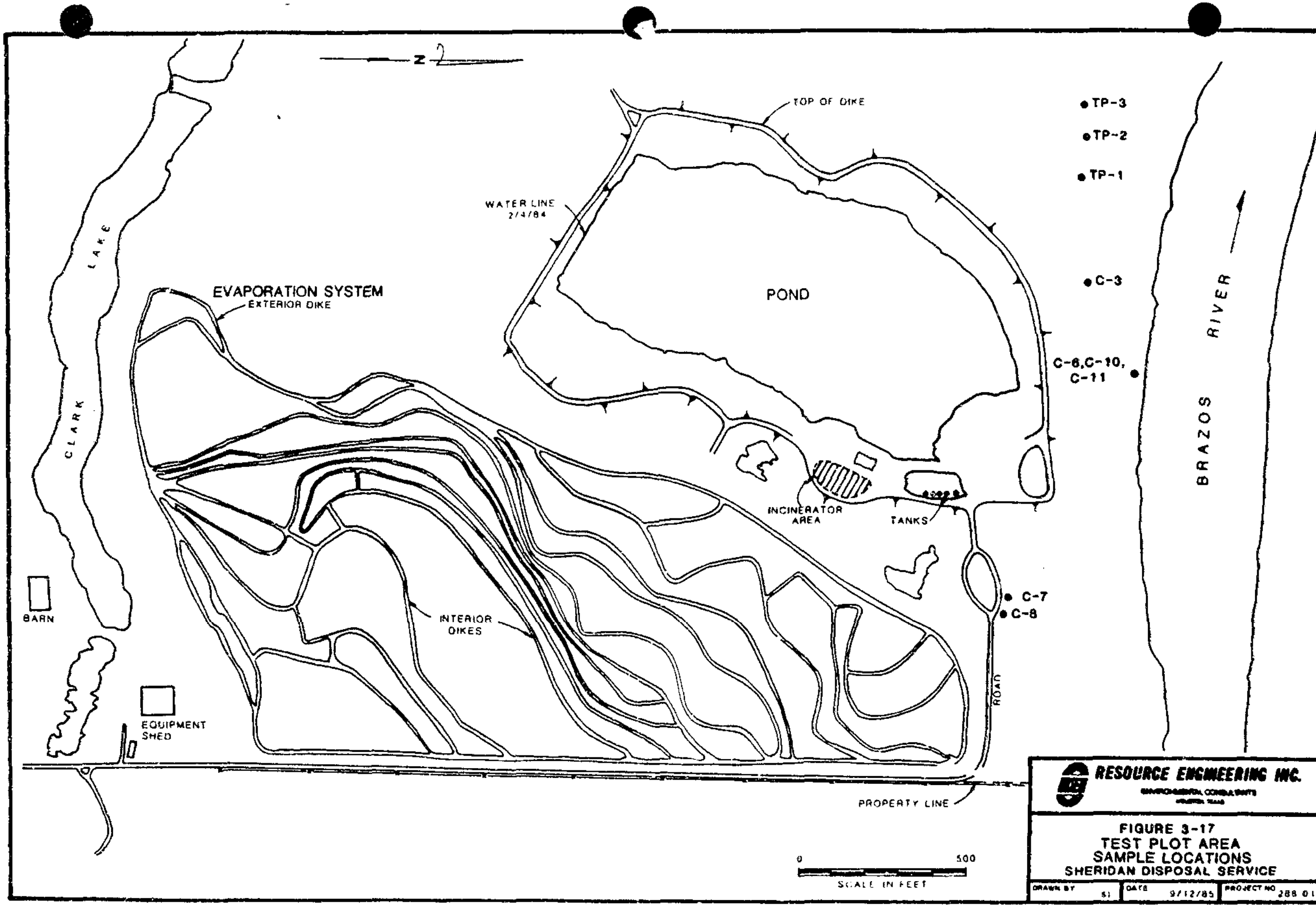

FIGURE 3-17
TEST PLOT AREA
SAMPLE LOCATIONS
SHERIDAN DISPOSAL SERVICE

Table 3-22

Pond Road Network Soil Analysis
(December 1985 and March 1986)

Sample No.	Depth (inches)	Oil & Grease (mg/kg)	Zinc (mg/kg)
C-3	0-6	499	29
C-6	0-2	4.7%	770
C-7	0-6	6,351	119
C-8	0-6	285	28
C-10	18-24	4,956	25
C-11	18-24	313	32

3.2 Environmental Fate and Transport - The ultimate fate and mobility of chemical contaminants at the Sheridan Disposal Service site is an important variable in determining public health risks and the impact of a "no action" remedial alternative.

Since heavy metals have significantly different fate and transport characteristics than organic compounds, they are reviewed as a group. The organic compounds of concern were analyzed using a MacKay equilibrium model to determine in which media phase (air, water, soil, sediments, or biota) the compounds had a tendency to concentrate (Appendix 3C, Section 3.2.2). The physical properties of each compound are tabulated and the impact on transport properties is discussed. The most significant transport mechanism, volatilization, is reviewed in detail as well as chemical and biological degradation processes.

The following conclusions are based on fate and transport properties of the major organic compounds of concern.

- Ultimate fate modeling of the organic chemicals indicates the majority of pollutants on a mass basis will volatilize in the air phase. Only phenols and 2,4-dichlorophenol will concentrate in water to any significant degree. PCBs and PNAs will remain adsorbed to soils underneath the pond and are the least mobile of pollutants at the site.
- Priority pollutants represent less than 5 wt.% of the pond sludge. A majority of the priority pollutants found are volatile compounds--predominantly toluene, ethylbenzene and benzene. All these compounds have standard volatilization half-lives less than six hours when in pure form. Volatilization is a significant transport mechanism for the organic compounds of concern. The primary impact of volatilization is in considering fate and transport of pollutants in the evaporation system.
- Most organic compounds of concern are highly volatile from dry soils. The exceptions are: phenol, which is moderately volatile; PCBs, which are slightly volatile; and PNAs which are nonvolatile.

- Biodegradation is a significant removal mechanism for xylene, toluene, benzene, ethylbenzene, 2,4-dichlorophenol and phenol (Jamison et al., Lyman et al., U.S. EPA, 1982). Biodegradation is the most likely removal mechanism for pond accumulated stormwaters treated successfully in the evaporation system. Biological treatment is a potential remedial treatment option for these compounds.
- A literature search has indicated atmospheric and surface water degradation rates are significant for many organic compounds of concern (Table 3-27). Valid modeling of off-site risks and impacts should include these degradation rates.

3.2.1 Heavy Metals - Overall soil conditions at the site do not favor the mobility of heavy metals. Given the clay thickness in aquitard layers, heavy metal migration to groundwater should not be a concern. The major removal (immobilization) mechanism for heavy metals is adsorption onto soil constituents. The major soil constituents involved in adsorption processes include clay minerals (layered alumina silicates), hydrated metal oxides (primarily iron oxides and manganese oxides) and organic matter. The major soil type at the SDS site is the Brazoria Association which is 95 to 100% clays and has a fairly high organic matter content of 2 to 6%. This is an excellent soil type for immobilization of heavy metal species. Site boring logs indicate the evaporation system is composed of Brazoria clay topsoil. Clemville (silt loam) and Oklared (very fine sandy loam) soils also occupy the northern extent of the sites. Clemville consists of 15 to 50% clays and Oklared soils contain 10 to 44% clays. Adsorption is also dependent upon soil pH, oxidation-reduction conditions, and to a lesser extent, on soil moisture and concentrations of inorganic salts.

The cation exchange capacity of typical soils in the evaporation system averages 51 milliequivalents/100 gms of soil (Table 3-13). This value indicates that the negatively-charged, clay soils at the site have a significant capacity to attract and immobilize positively charged ions such as heavy metal cationic species. This cation exchange capacity is not representative of the Oklared soil type found in the north section of the site.

Clay minerals exhibit different adsorption preferences for various metallic species and inorganic salts. There are a fixed number of "adsorption sites" on the clay particles; and metal species are in competition with inorganic salts and organics for these sites. Farrah and Pickering (1976) found the following order of preferences for different clay minerals:

Montmorillonite: Ca > Pb > Cu > Mg > Cd > Zn

Illite: Pb > Cu > Zn > Ca > Cd > Mg

Kaolinite: Pb > Ca > Cu > Mg > Zn > Cd

The predominant clay minerals at the site are illite and kaolinite as indicated by X-ray diffraction analysis of the sludge and pond bottoms soils (Table 3-3). As indicated, lead is preferentially adsorbed on all soil types, while zinc is less preferentially adsorbed and therefore more mobile in general.

Soil geochemistry of metal species is strongly controlled by the soil pH and oxidation potential (Eh). Soil pH changes affect the surface charge on adsorption sites and can solubilize solid phases of some metal species, while precipitating others. In general, alkaline conditions at the SDS site favor the mobility of zinc and chromium while restricting the mobility of nickel and lead.

The oxidation potential affects stability of hydrated metal oxides and level of microbial activity in soils. Oxidation potentials are lowered by anaerobic conditions in soils caused by high moisture content. The stability of metal species is often expressed in pH-Eh diagrams; these outline stable zones for each metal species. The soil conditions in the evaporation system at the SDS site are generally alkaline (pH 8.0 to 8.7) with low oxidation potential expected during those portions of the year when the soil moisture content is high.

Chromium levels in the evaporation system soils ranged from <1.4 to 56 mg/kg. The surface sludge at sample location 13 contains chromium at levels up to 207 mg/kg. The earlier sampling in May of 1984 detected chromium levels up to 78mg/kg. The pond sludge at sample location 13 is a different sample media which is not representative of the evaporation system soils. Sample point 13 is a worst case sampling point taken at the inlet cell to which pond wastewater was pumped to initiate evaporation. As previously discussed (page 3-37) the upper two feet of material at this location is a weathered, organic sludge and not a soil sample, in contrast to the other evaporation system samples.

Chromium mobility is inhibited by aerobic soil conditions and high soil concentrations of clays, organic matter, and hydrous oxides of iron, manganese, and aluminum. The existing soil conditions of high clay and organic matter content are more significant than the anaerobic conditions, which favor mobility. Overall conditions in the evaporative system do not favor chromium mobility. Considering the relatively low levels found and its transport characteristics, chromium is not likely to migrate.

Chromium exists in either the +3 or +6 oxidation states; the latter is much more toxic. Eh and pH conditions of the evaporation system probably favor the +3 oxidation state.

Lead concentrations in the evaporation system soils ranged from 5 to 188 mg/kg. The sludge at sample location 13 contained a maximum of 691 mg/kg lead. Eh and pH conditions in the evaporation system generally favor the stability of lead carbonate ($PbCO_3$ cerussite). This condition is similar to other water systems which precipitate cerussite. The existing soil conditions of high cation exchange capacity, alkaline soils, high clay and organic matter content indicate unfavorable conditions for lead mobility.

Nickel levels in the evaporation system ranged from <1.4 to 44 mg/kg. Nickel mobility is inhibited by aerobic soils, high pH and high clay and organic matter content in soils. Existing soil properties such as high clay and organic matter content and alkaline conditions favor adsorption of nickel in the evaporation system. Nickel is not a concern at the site.

Zinc levels in the evaporation system soils ranged from 22 to 145 mg/kg. The range of concentrations of water leachable zinc in soils is from 2 to 30 mg/kg.

Among the heavy metals, zinc was found at the highest levels both in sludge and evaporation system soils. Soil properties indicate zinc is the least immobilized heavy metal of concern at the site. The best correlations of heavy metal and oil and grease concentrations is with zinc. Because of these factors, zinc is the best potential candidate for a heavy metal indicator parameter.

3.2.2 Equilibrium Properties of Organic Contaminants- The distribution of chemicals in various environmental media can be estimated from physical properties. A model has been suggested by MacKay (1979) based on a chemical's fugacity. Fugacity is best defined as a thermodynamic "escaping tendency." In an environmental system at equilibrium, the fugacity of a pollutant is the same in all phases.

MacKay's Level I model assumes all the environmental media compartments (air, water, soils, sediments and aquatic biota) are directly or indirectly connected and the pollutants have the necessary time to reach equilibrium. The EPA has used this model in a recent series of exposure and risk assessment documents for priority pollutants (EPA-440/4-85-020).

Table 3-23 presents the results of a MacKay equilibrium model for the organic pollutants of concern at the Sheridan Disposal Service site. Table 3-23 shows the percentage of each compound in each media phase at equilibrium for the site. The model indicates that the aromatic and volatile chlorinated solvents will predominate in the air phase if allowed to reach equilibrium. This is evident when weathered sludge composition is compared to the pond sludge. Without a water or oil barrier to prevent volatilization, these compounds would quickly evaporate from the sludge. Model calculations are presented in Appendix 3C.

Table 3-23

Percent Partitioning of Organic Contaminants in a Rural Environment

Compound	Air	Water	Soil	Sediment	Biota
Chloroform	99.92	0.014	0.067	0.002	~0.0
Tetrachloroethylene	99.92	0.002	0.083	0.0003	~0.0
Trichloroethylene	99.92	0.004	0.076	0.003	~0.0
Benzene	99.90	0.007	0.089	0.004	~0.0
Xylene	99.79	0.006	0.202	0.007	~0.0
Toluene	99.71	0.006	0.27	0.01	~0.0
1,1,1-Trichlorethane	99.67	0.035	0.284	0.011	~0.0
Ethylbenzene	98.95	0.006	1.00	0.037	~0.0
Phenol	26.96	24.13	47.15	1.75	~0.0
2,4-Dichlorophenol	10.36	1.53	84.96	3.14	~0.0
PCBs	3.57	0.001	93.04	3.38	0.001
PNAs (Benzopyrene)	0.0005	0.0001	96.43	3.57	~0.0

Rural environment was chosen as a unit world model.

The model predicts phenol and 2,4-dichlorophenol as the major contaminants which would be present in the water phase. This is consistent with GC/MS analysis of the pond water and the solubility data for these compounds. PCBs and PNAs will remain primarily adsorbed in the sediments. The physical properties of the major organic compounds at the site which are most important in assessing transport characteristics are presented in Table 3-24. (Representative compounds were tabulated for the chemical groups of PCBs and PNAs.) A summary of the significance of these properties follows.

Phenol has an order of magnitude of greater water solubility (93,000 mg/l) than the other organic compounds of concern. This explains its predominance in the pond stormwater (Table 3-10). The volatile chlorinated solvents and 2,4-dichlorophenol are also slightly soluble, while PCBs and PNAs are relatively insoluble. Since chemical transport via groundwater and surface water is highly dependent upon water solubility, this is an important variable.

Vapor pressures, expressed in mmHg (760mmHg = 1 atmosphere), indicate chloroform, trichloroethylene, and benzene are the most volatile compounds present at the site; PCBs and PNAs are slightly to nonvolatile. A chemical's rate of volatilization from water is estimated from Henry's law constant, with volatilization rates decreasing with decreasing

Table 3-24
Physical Property Data for Select Organics

Compound	Formula	CAS#	Molecular Weight (gms/mole)	Density (g/cc 25°C)	Melting Point (°C)	Boiling Point (°C)
Chloroform	$CHCL_3$	67-66-3	119.4	1.483(20°C)	-63.5	61.7
Tetrachloroethylene	C_2Cl_4	127-18-4	165.8	1.623	-19	121
Trichloroethylene	$ClCH{=}CCl_1$	79-01-6	131.4	1.464(20°C)	-73	87
Benzene	C_6H_6	71-43-2	78.1	0.873	5.5	80.1
(m,p,o)-Xylene	$C_6H_4(CH_3)_2$	1330-20-7	106.2	0.857 to 0.876	-48 to 13	138.3 to 144.4
Toluene	$C_6H_5(CH_3)$	108-88-3	92.1	0.862	94.99	110.6
1,1,1,Trichloroethane	CH_3CCl_3	71-55-6	133.4	1.339 (20°C)	-30.4	74.1
Ethylbenzene	C_8H_{10}	100-401-4	106.2	0.871(15.5°C)	-94.98	136.2
Phenol	C_6H_5OH	108-95-2	94.1	1.058(20°C)	40.9	181.8
2,4,-Dichlorophenol	$Cl_2C_6H_3OH$	120-83-2	163.0	NA	45	210
PCB's (2,4,2'4'-Tetrachlorobiphenyl)	$C_{12}H_{-10}XCL_x$	1336-36-3	291.9	NA	41	NA
PNA's (Benzo(a)pyrene)	$C_{20}H_{12}$	50-32-82	252.3	NA	175	311

NA - Not Available

CAS - Chemical Abstracts Service

Table 3-24
Physical Property Data for Select Organics
(continued)

Compound	Water Solubility (mg/1 @ 25°C)	Vapor Pressure (mm Hg @20 - 30°C)	Henry's Law Constant (ATM-M^3/MOL)	Soil Adsorption Partition Coefficient (K_{oc} ml/g)	Octonol/ Water Partition Coefficient Log (K_{ow})	Biological Concentration Factor (BCF)
Chloroform	8,000	151.1	2.87E-03	31	1.97	3.75
Tetrachloroethylene	150	17.8	2.59E-02	364	2.6	31
Trichloroethylene	1,100 - 1,470	57.9	9.10E-02	126	2.38	10.6
Benzene	610 - 1,780	95.2	5.59E-03	83	2.12	5.2
(m,p,o)-Xylene	175 - 198	10.0	7.04E-03	240	3.26	NA
Toluene	535 - 566	28.1	6.37E-03	300	2.73	10.7
1,1,1,Trichloroethane	4,500	30.0	1.17E-03	56	2.47	5
Ethylbenzene	152	7.0	6.43E-03	1,100	3.15	37.5
Phenol	93,000	0.34	4.57E-07	14.2	1.46	1.4
2,4,-Dichlorophenol	4,600	0.059	2.75E-06	380	2.90	41
PCBs (2,4,2'4'-Tetrachlorobiphenyl)	0.031 - 0.068	7.7E-05	1.07E-03	53,000	6.04	70,500 to 100,000
PNA's (Benzo(a)pyrene)	0.0012 - 0.0038	5.6E-09	1.55E-06	5.5E+06	6.06	NA

NA - Not Available

Henry's law constants. Volatilization rates for the organics of concern will be discussed further in Section 3.2.3.

The soil adsorption partition coefficient (Koc) is a measure of a compound's tendency to be adsorbed by clay minerals and organic matter. Soil adsorption tendencies increase with increasing Koc values.

The octonol-water partition coefficient (Kow) is an important parameter used to estimate a wide range of environmental transport characteristics. Kow is a measure of how a chemical is distributed when at equilibrium conditions with water and octonol, identifying its preferential solubility in a two-phase water/organic matrix.

The biological concentration factor (BCF) is the ratio of the concentration of a chemical at equilibrium in fish to the mean concentration of that chemical in water to which the fish is exposed. The BCF is used to determine the significance of food chain accumulation of a chemical.

3.2.3 Volatilization - As shown in the MacKay model, volatilization is probably the most important transfer mechanism at the Sheridan site since most of the compounds of concern are volatile. Volatilization from the aqueous phase is dependent upon a chemical's solubility, vapor pressure, molecular weight, and the number and composition of liquid interfaces it must pass through to reach the atmosphere. Volatilization is also dependent upon ambient conditions such

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as wind speed, temperature, and relative humidity. Table 3-25 describes the relative volatility from water of the organics of concern.

The EPA has recently completed a study entitled (EPA - 450/3-85-007, 1985) "Physical Chemical Properties and Categorization of RCRA Wastes According to Volatility" which contains data on relative volatilization rates from dry and wet soils. Table 3-26 summarizes the available data for the organic compounds of concern. The relative volatility values are categorized within Table 3-26. 0035255

3.2.4 Biodegradation - Biodegradation is a significant removal mechanism for organics from soil and water systems. Higher organisms can metabolize organics, but the majority of biodegradation occurs through microbial degradation. Microbial biodegradation is the basis for activated sludge treatment of industrial wastewaters which contain organics such as phenol.

Microorganisms biodegrade organics through acclimation and production of specific enzymes for metabolism. Specific enzyme reactions which are applicable are;

- oxidative dealkylation as in the degradation of xylene and toluene;
- aromatic hydroxylation as in the reaction of benzene to phenol and catechol; and

Table 3-25

Relative Volatility from Water of Organic Compounds

Compound	Volatility	Henry's Law Constant H(ATM-M^3/MOL)	Volatilization Half-Life $t1/_2$ (Hours) (a)
Phenol	The compound is less volatile than water and its concentration will increase as the water evaporates.	$H < 3x10^{-7}$	
PNAs	The compound volatilizes at a rate dependent on H. The gas-phase is more resistant than the liquid phase by at least a factor of 10. Slow molecular diffusion through air controls the rate of volatilization.	$10^{-7} < H < 10^{-5}$	NA
2,4-Dichlorophenol			5.6
1,1,1-Trichloroethane	The compound volatilizes rapidly; the liquid-phase resistance controls the rate of volatilization.	$H > 10^{-3}$	3.7
Chloroform			3.7
Benzene			4.8
Toluene			5.26
Ethylbenzene			NA
Xylene			3.2
Tetrachloroethylene			NA
Trichloroethylene			3.4

NA - Not available.

(a) 1 meter mean depth of water body

Source - Lyman, W.J., Reehl, W.F., Rosenblatt, P.H. 1982. Handbook of Chemical Property Estimation Methods, Environmental Behavior of Organic Compounds New York: McGraw-Hill.

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Table 3-26

Volatility of Organics from Soil

Compound	Relative Dry Soil Volatility (P_{vp} MW $^{-1/4}$)	Relative Wet Soil Volatility (P_{vp} MW $^{-1/2}$)
Chloroform	51.6	15.8
Benzene	34.3	11.4
1,1,1 Trichloroethane	33.9	10.1
Toluene	8.6	2.8
Tetrachloroethylene	5.0	1.4
Ethyl Benzene	2.2	0.68
(m,p,o)-Xylene	0.98 - 2.05	0.27 - 0.31
Phenol	0.2	0.064
PCBs	1.9×10^{-5}	4.5×10^{-6}
PNAs	4.8×10^{-11}	1.2×10^{-11}

Source: U.S. EPA, 1985. EPA-450/3-85-007. "Physical Chemical Properties and Categorization of RCRA Wastes according to Volatility"

- Highly volatile - Relative soil volatility greater than 1.
- Moderately volatile - Relative soil volatility from 1 to 10^{-3}.
- Slightly volatile - Relative soil volatility from 10^{-3} to 10^{-6}.
- Nonvolatile - Relative soil volatility below 10^{-6}.

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- aromatic non-heterocyclic ring cleavage as in the degradation of catechols and phenols.

The microorganisms primarily responsible for biodegradation include protozoa, diomycetes and yeasts, fungi, some autotrophic bacteria, and heterotrophic bacteria. The majority of microorganisms are found in the top 6 inches of soil; their number averages 10^8/gm of soil in typical soil systems (Lyman et al,) 1982.

Factors which influence the rate of biodegradation include:

- Ambient conditions: temperature, pH, soil moisture content, oxygen availability, inorganic salt concentration, and availability of nutrients such as nitrogen and phosphorous.
- Organic compound characteristics: toxicity of compound, initial concentration, soil adsorption and water solubility properties.
- Microorganism characteristics: species diversity, soil concentration of organisms, enzyme metabolism systems available, previous exposure and acclimation to the specific organic compound.

Table 3-27 is a comparison of the biodegradability of the significant organic contaminants at the Sheridan Disposal Service site. Although the BOD_5 test is not standardized, it does allow for relative comparisons such as in

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Table 3-27

Biodegradability of Organic Contaminants

Compound	BOD_5/COD Ratio[1]	Biodegradation Rate Completion % (Based on Aqueous COD)	Average Rate of Biodegradation (Mg $CODg^{-1}$ HR^{-1})
Relatively Nonbiodegradable			
Chloroform	~0	-	-
Tetrachloro-ethylene	~0	-	-
Relatively Biodegradable			
O-Xylene	<0.008	100[2]	N/A
M-Xylene	<0.008	100[2]	N/A
Ethylbenzene	<0.009	100[2]	N/A
P-Xylene	<0.11	N/A	N/A
Toluene	<0.12	N/A	N/A
Benzene	<0.39	N/A	N/A
2,4-Dichloro-Phenol	0.78	98.0	10.5
Phenol	0.81	98.5	80.0
Common Degradation Products			
Cresols	0.57 - 0.68	95-96	55.0
Benzaldehyde	0.62	99.0	119.0
Benzoic Acid	0.84	99.0	88.5

NOTE: N/A - Not available

1 - The BOD_5 test is dependent on the acclimation of the initial seed organisms and therefore results may not be directly comparable for all compounds

Sources - Pitter (1976) and Lyman (1982)

2 - Samison, V. W., D.L. Raymond, and J.D Hudson, 1976. "Biodegradation of High-Octane Gasoline."

Table 3-27. As indicated in that table, biodegradation is a significant environmental fate path for toluene, benzene, 2, 4-dichlorophenol and phenol, as well as for dealkylation and hydroxylation degradation products of more complex organics.

The biodegradation rate of phenol has been extensively studied in wastewater treatment systems. Past studies indicate kinetic reduction rates of 0.013 to 7.6 ug/l/hr. The acclimation of organisms to phenol is the factor which most affects biodegradation rates. At concentrations up to 10 mg/l almost complete degradation occurs. Oxygen uptake in water systems is inhibited by phenol concentrations of 10 to 100 mg/l, but microorganisms have been observed to treat phenol levels of up to 500 mg/l successfully. Since phenol is the major organic compound of concern in the pond stormwater, biological treatment is a possible remedial treatment for pond stormwater EPA-440/4-85-013, 1981 "An Exposure and Risk Assessment for Phenol".

The discharge of phenol to water systems can cause rapid growth of microbial populations which can cause dissolved oxygen levels to be reduced up to 100%. Significant oxygen depletion causes suffocation of fish and invertebrates. This is the most likely explanation for the Clark Lake fish kill which was reported in 1978. Table 3-28 is a summary of potential effects of a phenol spill in a river system. It should be noted that the pond stormwater has a phenol concentration of 3.5 ppm which is only marginally toxic to

Table 3-28

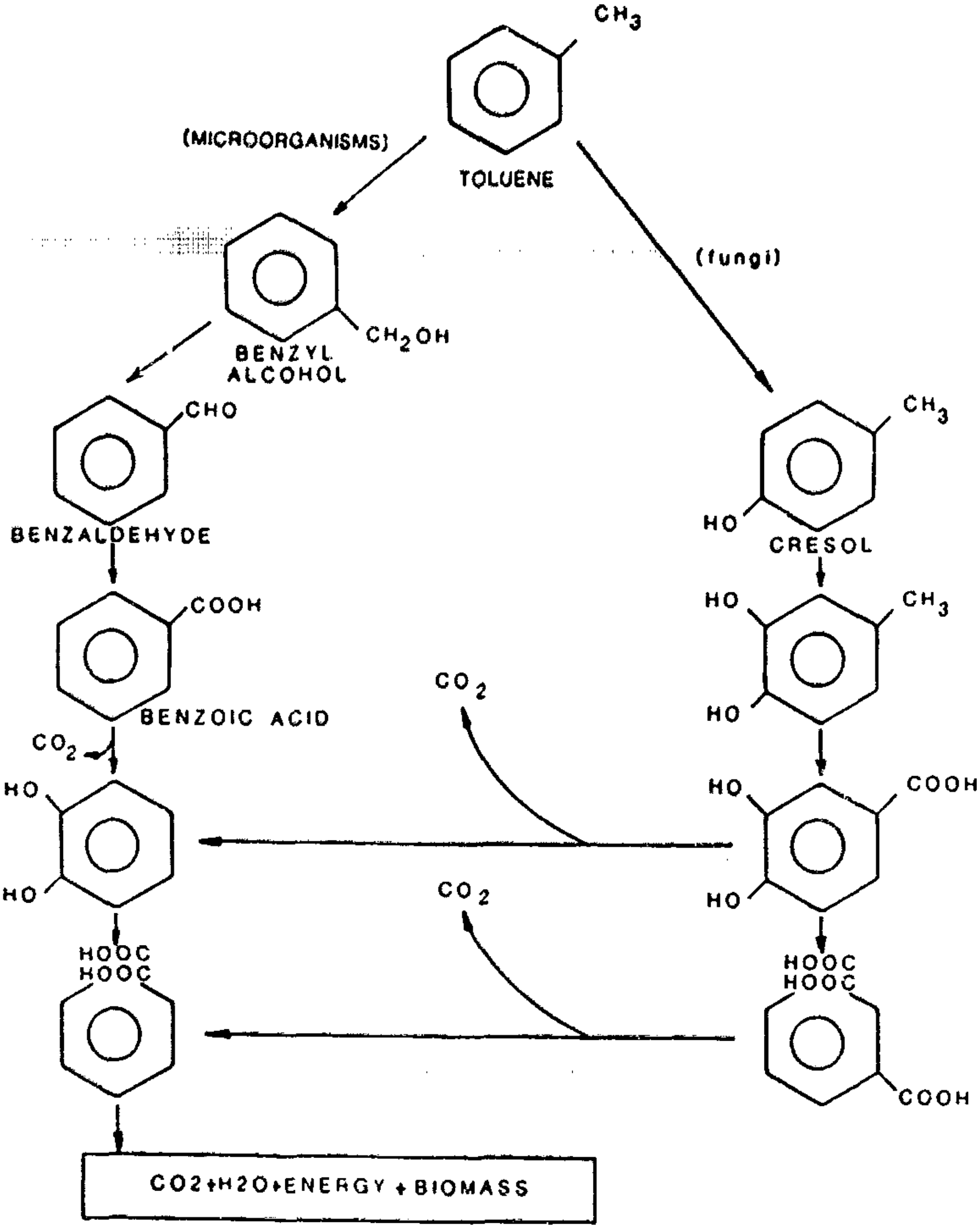
Effects of a Phenol Spill on a River System

Phenol Concentration (mg/l)	Oxygen Deficiency (%)	Effect
3 - 10	50 - 90	Only salmonid population killed; slight effect on aquatic flora.
<3	<50	No damage.

Source: Krombach and Barthel, 1964. "Investigation of a Small Water-Course Accidentally Polluted by Phenol Compounds," Adv. Was. Pollut. Res. 1: 191-203.

salmonid populations. Considering phenol alone, the effects of a major stormwater spill would impact only Clark Lake and local drains and creeks. The Brazos River would not be adversely affected due to dilution considerations.

Toluene biodegradation in soils is a significant environmental fate process. The EPA reported in a document entitled (EPA-440/485-016, date "An Exposure and Risk Assessment for Toluene" (EPA-440/485-016) that researchers have measured the degradation half-life of toluene to be 20 to 60 minutes in soil with acclimated bacteria. Ultimate biodegradation rate completions of 20 to 60% are observed in tests involving toluene leachate through sandy soils. Figure 3-18 shows the typical biodegradation pathways for toluene.



SOURCE - RCRA RESEARCH (1984)

RESOURCE ENGINEERING INC.
ENVIRONMENTAL CONSULTANTS
HOUSTON, TEXAS

FIGURE 3-18
TOLUENE BIODEGRADATION PATHWAY
SHERIDAN DISPOSAL SERVICE

DRAWN BY: N.L.J.	DATE: 8-26-85	PROJECT NO. 288-04

The majority of the toluene at the site is in the pond sludge under anaerobic conditions. Anaerobic biodegradation occurs at a rate 20 to 40 times slower than aerobic biodegradation. The most likely fate of toluene transferred to the evaporation system through pond stormwater would be biodegradation under aerobic conditions or volatilization.

3.2.5 <u>Chemical Transformation</u> - Chemical reactions are the major removal path for volatile organics in the atmosphere. Atmospheric reactions occur with hydroxyl radicals (OH^-); ozone (O_3) and through photolysis. For most organic compounds reactions with hydroxyl radicals are by far the most important. Since these reactions are basically first order in kinetics, their half-lives in the environment can be estimated.

Benzene and its alkyl substitutes do not adsorb sunlight or undergo photolysis. Photolysis is significant only for PCBs and PNAs. Benzo(a)pyrene, a PNA, has been reported to have a sunlight half life of 0.045 days and 2,2',5,5' tetrachlorobiphenyl a half life of 2.5 days (EPA-440/4-85-019).

Aqueous hydrolysis is another significant chemical transformation in the environment. However, functional groups which are resistant to hydrolysis include:

- benzene
- biphenyl

- polycyclic aromatic hydrocarbons
- halogenated hydrocarbons
- phenols.

This list includes the organics of concern at the SDS site; therefore aqueous hydrolysis is not considered a significant fate path.

Table 3-29 contains a summary of the persistence of the organics of concern in both the atmosphere and in surface water which takes into account all significant degradation pathways.

Table 3-29

Persistence of Major Organic Contaminants at the Sheridan Disposal Services Site

Compound	Atmospheric Hydroxyl Radical Reaction Rate K_{OH} In CM^3 $Molec^{-1}s^{-1}$	Atmospheric Half Life[1] $t_{1/2}$ (Days)	Surface Water Half Life $t_{1/2}$ (Days)
Xylene	1.3×10^{-11}	0.62	1.5 - 9.0
Ethyl Benzene	7.5×10^{-12}	1.1	1.5 - 7.5
Toluene	5.9×10^{-12}	1.3	0.17
Trichloroethylene	2.0×10^{-13}	4.0	1 - 90
Phenol	-	0.62 - 9.0	0.62 - 9.0
PNA's (Benzo(a)pyrene)[2]	-	1.0 - 60	0.40
Benzene	1.4×10^{-12}	5.7	1.0 - 6.0
2,4- Dichlorophenol	-	23	6.0
Tetra Chloroethylene	1.7×10^{-14}	47	1 - 30
Polychlorinated Biphenyls (PCBs)	-	58.0	2.0 - 12.9
Chloroform	1.1×10^{-14}	73	0.3 - 30
1,1,1- Trichloroethane	1.5×10^{-15}	530	0.14 - 7.0

1 - Environmental half-lives are based on 24-hr days assuming an atmospheric OH^- concentration of 1×10^6 radicals CM^{-3}.
2 - Benzo(a)pyrene has a reported half-life in soil of 420-480 days.

References

(a) SRI International, June, 1979. "Atmospheric Reaction Products of Organic Compounds, "EPA-560/12-79-001.

(b) ECAO 1985. ECAO Health Effects Assessments.

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4.0 HYDROGEOLOGY AND SOILS

The hydrogeological and soils investigation for the Sheridan Disposal Service (SDS) site consisted of two main phases:

- historical data review, and
- field investigations.

The historical data review was regional, while the field investigations were site specific.

The historical data review was based mainly on published and unpublished reports on the area. It yielded enough information to formulate a working conceptual model of the groundwater flow system. This model was used to design the site-specific, field investigation activities.

Twenty monitoring wells, 9 borings and 20 cone penetrometer soundings provided site specific, data-gathering points for soils, geological and hydrogeological, information. The location of these investigations is shown on Figure 4-3.

The following subsections present the conclusions from the hydrogeologic and soils investigation. Refined conceptual model and methods and procedures presented in Sections 4.2 - 4.6 and Appendices 4A-4H, respectively, support these conclusions.

003540

4.1 Conclusions

- The two near-surface aquifer systems immediately beneath the site consist of an upper unconfined aquifer (Strata A and B) and a confined water table aquifer (Stratum D). A clay aquitard (Stratum C) separates the confined aquifer from the unconfined aquifer.
- There is the potential for a hydraulic connection between the water table aquifer (Stratum B) and the first confined aquifer (Stratum D) at the SDS site. However, the realization of this connection is unlikely in view of the predominantly upward gradient from the confined aquifer.
- The water table aquifer is in direct hydraulic connection with the Brazos River at the SDS site. The first confined aquifer may be hydraulically connected to the Brazos River.
- There are no faults or other geological features near the site that could provide pathways for contaminant migration to deeper zones.

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- There is no hydrologic pathway which would transmit contaminants from the water table aquifer (Strata A and B) thru the Brazos River into the first confined aquifer (Stratum D).

- Groundwater flow within the site boundary from the upper water table (Strata A and B) into the Brazos River is approximately 7.1 gallons per minute (gpm). The Brazos river flow at Hempstead Station is approximately 1.2 million gpm during low flow conditions. 003542

4.2 Geology

4.2.1 Regional Geology - The Sheridan Disposal Service (SDS) site is located in the Brazos River drainage basin. The Brazos River flows across the Central Texas section of the Great Plains Physiographic Province onto and across the West Gulf Coastal section of the Coastal Plain Province. The Brazos River discharges into the Gulf of Mexico near Freeport, Texas.

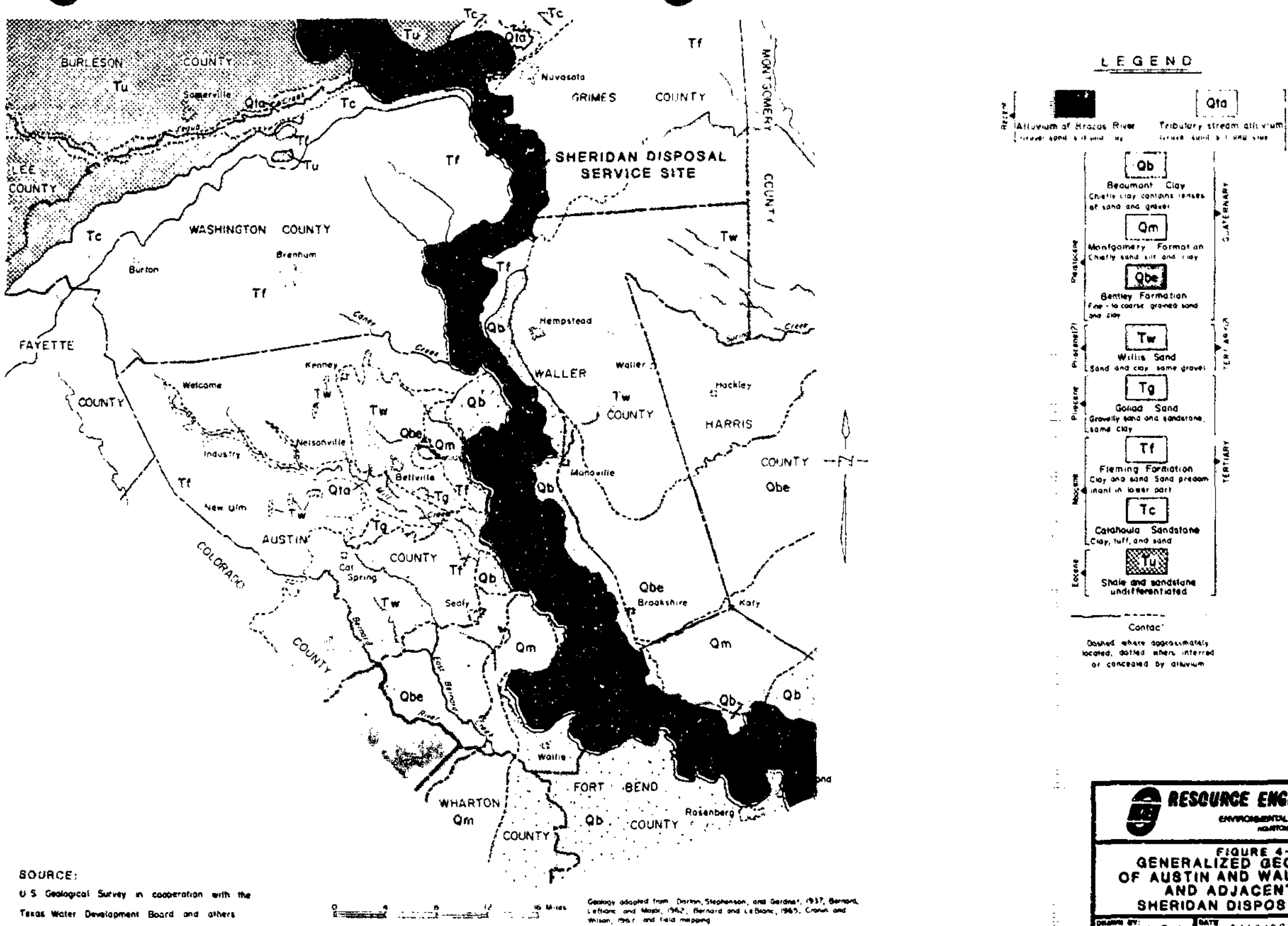
The Brazos River drainage basin has evolved through numerous geologic cycles. The latest cycles relate to the episodic advance and retreat of glaciers during the Pleistocene Epoch. The advance and retreat of the glaciers caused periods of deposition alternating with periods of erosion. As glaciers advanced and sea level was lowered, streams flowing across the Gulf Coastal Plain entrenched themselves by eroding vertically. As glaciers retreated, sea level rose, and sediment began filling these stream channels.

Many unconsolidated sedimentary units are exposed in the Brazos River drainage basin. Seven geologic units crop out between the SDS site and the Gulf of Mexico. Figure 4-1 shows the location of these units between the SDS site and northern Fort Bend County. From oldest to youngest, they include: Fleming Formation, Goliad Sand, Willis Sand, Bentley Formation, Montgomery Formation, Beaumont Clay, and recent alluvium of the Brazos River. Their general characteristics are profiled in Table 4-1.

The seven units (formations) are composed of unconsolidated, interbedded sand, silt, and clay. Unit thickness and water bearing characteristics vary with location. Generally, each of the seven units may yield small to large amounts of fresh or slightly saline water from their more permeable zones.

These formations were deposited under a variety of conditions including marine, continental and intermediate (mixed). Younger units crop out near the coast, while older units appear farther inland at higher elevations. The units tend to dip more steeply and thicken towards the Gulf of Mexico.

As shown in Figure 4-1, the SDS site is located in the recent alluvium of the Brazos River. The recent alluvium of the site overlies the Fleming Formation. The



SOURCE:

U S Geological Survey in cooperation with the Texas Water Development Board and others

Geology adapted from Darton, Stephenson, and Gardner, 1937, Bernard, LeBlanc and Major, 1962, Bernard and LeBlanc, 1965, Cronin and Wilson, 1967 and field mapping

RESOURCE ENGINEERING INC.
ENVIRONMENTAL CONSULTANTS
HOUSTON, TEXAS

FIGURE 4-1
GENERALIZED GEOLOGIC MAP
OF AUSTIN AND WALLER COUNTIES
AND ADJACENT AREAS
SHERIDAN DISPOSAL SERVICE

DRAWN BY: L.C.S.	DATE 2/18/86	PROJECT NO. 288-04

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Table 4-1
Geologic description and water-bearing properties of the geologic units forming the aquifers in Austin and Waller Counties

Aquifer	Stratigraphic unit	Estimated thickness in area (feet)	General composition in Austin and Waller Counties	Surface expressions	Water-bearing properties in Austin and Waller Counties
Alluvial	Tributary alluvium and flood-plain alluvium of the Brazos River	0- 80	Unconsolidated gray, brown, and reddish-brown clay, silt, and sandy clay, commonly overlying light-colored sand or coarser-grained sand and gravel.	Occurs along the banks of smaller streams and in the flood plain of the Brazos River. Nearly flat plain. Forms reddish to dark-brown and black soils.	Yields small to large amounts of fresh water in the flood plain of the Brazos River.
Evangeline	Beaumont Clay	0- 75	Mottled red, reddish-brown, brown and gray, dense clay with white calcareous nodules. May contain lenses of fine and medium-grained sand or sand and gravel in places.	Occurs only along the fringes of the Brazos River flood plain. Forms nearly flat, narrow plain. Soils are gray to black, blocky.	Yields small to moderate amounts of water to scattered shallow wells less than 100 feet deep along the edge of the Brazos River flood plain.
	Montgomery Formation	0- 40?	Light gray to light brown, fine-grained sand, silt, and clay, probably grading with depth to darker-colored coarser sand and in places basal sand and gravel.	Nearly flat, featureless plain; soils are light colored, fine-grained sandy. Occurs only along southern edge of area.	Yields small amounts of water to scattered shallow wells.
	Bentley Formation	0- 50?	Alternating beds of reddish-brown to yellow and gray, mottled clay interbedded with grayish, fine- to coarse-grained sand and gravel lenses. Scattered lentils of lime-cemented sandstone. Clay, sandy clay, and fine sand predominate in the upper part, darker-colored coarser sand and gravel in the lower part.	Forms flat plains in the southern one-third of the counties; most of the rice-growing area is on the outcrop. Forms light-colored sandy loam soils.	Contributes small to moderate amounts of fresh water to domestic wells in the southern part of the area; probably represented by the uppermost sands screened in these wells.
	Willis Sand	0- 240?	Alternating beds of mottled red, yellow, brown, and gray clay and sand with scattered lenses unsorted sand and quartz gravel. Ferruginous nodules common. Packed and hard in fresh exposures. Basal part is usually a hard, gravelly sand and clay.	Forms the gently-rolling sand hills of northern Waller County and central Austin County. Most of the gravel pits in Austin County are in the basal Willis. Forms tan sandy soils.	Yields small to large amounts of fresh water to wells.
	Goliad Sand	0- 840?	White to gray, sticky, calcareous clay with interbedded lenses of light-colored, gravelly sand and lime-cemented sandstone. Black chart grains in the whitish sand give a salt and pepper effect.	Occurs as isolated surface exposures because the Goliad is overlapped by the Willis Sand or is easily removed by erosion. Forms gray, sticky soils. Usually occurs along valley bottoms and walls.	Yields large amounts of fresh water to wells.
Burkeville Aquiclude	Fleming Formation	0-1,700	Interbedded clay and sand; clay predominantly in the upper part. The blocky, dense clay is various shades of gray, yellow, olive, and brown. White calcareous nodules are common. Sand is gray to brown, brown, interbedded with gray clay. Sand is medium to fine grained and often cross-bedded.	Forms the rolling and dissected topography of northern Austin County. Forms gray to black loam and sandy loam soils.	Yields small to large amounts of fresh to slightly saline water.
Jasper	Catahoula Sandstone	?	Alternating beds of gray clay, tuff, and sand. Lower sands may be hard, white, and have opaline appearance.	Does not crop out in Austin or Waller Counties. Difficult to distinguish from overlying Fleming Formation in both surface exposures and in well logs.	May yield small amounts of fresh water in the most northern part of Austin County. Generally water is at least slightly saline.
	Undifferentiated	—	Alternating beds of gray sand, sandstone, and shale.	Does not crop out in Austin or Waller Counties.	Would yield only saline water.

Source: Texas Water Development Board, Report 68

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Fleming Formation is a thick formation of interbedded clay and sand with clay predominantly in the upper part.

No faults with surface expression occur in northern Waller and Washington counties shown on the Austin sheet of the Geologic Atlas of Texas. No geologic literature for the area reports faults or faulting at the SDS site. Surface and subsurface investigations conducted by Resource Engineering, Inc. (REI) revealed no evidence of faulting at the SDS site.

The Hockley escarpment and Hockley Salt Dome lie approximately 18 miles south of the site; the Millican fault zone lies approximately 20 miles to the north. However, there is no evidence that either the Hockley escarpment or the Millican fault zone have a structural or hydrologic influence on the SDS site.

4.2.2 Alluvium - Sea level changes associated with the advance and retreat of the glaciers during the Pleistocene controlled alluvial deposits. Sea levels declined as water accumulated in glaciers during glacial expansion. As they flowed to the more distant coastlines, rivers draining the coastal region of Texas entrenched their valleys. Sea levels rose to similar present day levels when the glaciers receded. The river valleys filled with alluvium during interglacial periods as the streams aggraded their channels. Deposition of sediment was mainly, as it is today, in the stream channels and on the floodplains during over bank flow.

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The composition of the floodplain alluvium varies laterally and vertically. The lenses of sand, silt, clay, and gravel are unconsolidated and pinch out or grade laterally and vertically into finer or coarser materials. Generally, the fine-grained material occurs in the upper part of the deposit; the gravel, whether mixed with sand and clay or clean and well sorted, is often found in the lower part of the deposit. A typical aggrading sequence consists of coarser material at the base, grading upwards to clay at the top.

The alluvium along the Brazos River is divided into two types: terrace and floodplain. Terrace alluvium, deposited in an earlier river cycle, is currently found above and adjacent to the present floodplain. In places, the terrace alluvium is geologically and hydrogically isolated from the floodplain alluvium.

After a decrease in stream base level, a new erosion/deposition cycle began and cut into what is now terrace alluvium deposits. The floodplain alluvium is the most recently deposited material in the area. It is located in the current floodplain of the Brazos River. The SDS site is located entirely within the floodplain alluvium.

4.2.3 Soils

Soils near the project site consist of a series of bottom land and upland soils. They are mainly clayey to loamy soils. Pasture and cultivated crops account for the largest portion of agriculture land use in Waller County. Soils at the SDS site are discussed in more detail in Section 4.4.2.

4.3 Regional Hydrology

4.3.1 Groundwater Regime

4.3.1.1 Regional Groundwater - Groundwater is the area's major source of water for municipal, industrial, domestic, and irrigation use. Fresh groundwater is available throughout the area, although it is underlain by a zone of slightly saline water. The geologic formations containing fresh and slightly saline waters are: the Catahoula Sandstone, Fleming Formation, Goliad Sand, Willis Sand, Bentley Formation, Montgomery Formation, Beaumont Clay, and recent alluvium of the Brazos River. Several formations have similar sequences of unconsolidated sediments that are hydraulically connected. They are thus easily divided into four hydrogeologic units: the Jasper Aquifer, Burkeville Aquiclude, Evangeline Aquifer, and the Brazos River Alluvium Aquifer.

The SDS site is located entirely within the Brazos Piver Alluvium Aquifer. The upper 55 feet of sands and clays at the SDS site are part of the Brazos River Alluvium Aquifer. Underlying this aquifer are several sand and clay layers which are part of the Fleming Formation.

It is uncertain if the Evangeline Aquifer underlies the SDS site, based upon available field data. The sand and clay layers at the SDS site, which are part of the Fleming Formation, may be part of the Jasper Aquifer, the Burkeville Aquiclude or the Evangeline Aquifer.

Parts of the Fleming Formation form the Burkeville Aquiclude, the Jasper Aquifer, and the Evangeline Aquifer. The Burkeville Aquiclude separates the Evangeline Aquifer from the Jasper Aquifer. The relative positions of these hydrologic units vary within the Fleming Formation and by location. The Fleming Formation is of Miocene age; as stated by E. T. Baker, Jr. in TDWR Report 236, 1979, "Stratigraphic and Hydrogeologic Framework of Part of the Coastal Plain of Texas," Miocene age formations are the most complex.

> "The stratigraphic framework of the units that are designated in this report as Miocene in age is complex and controversial, perhaps more so than any other Cenozoic units. Geologists do not agree which units on the surface or in the subsurface are Miocene nor do they agree as to the relationship of the surface and subsurface units. The correct relationship may never be determined because faunal markers, which exist in places in the subsurface, do not extend to the outcrop; and the heterogeneity of the sediments does not facilitate electrical-log correlations."

An example of these inconsistencies is shown in TDWR Report 236 which indicates that the Jasper Aquifer includes the lower third of the Fleming Formation and the Catahoula Sandstone. This is an apparent conflict with the hydrogeologic units shown in TDWR Report 68 and Table 4-1 of this report.

The deepest regional aquifer beneath the SDS site is the Jasper Aquifer. The Jasper Aquifer includes the lower part of the Fleming Formation and possibly part of the Catahoula Sandstone. The water in the Jasper Aquifer becomes saline with depth, generally over 1000 feet.

Few large water production wells tap the Jasper Aquifer in northwestern Waller County; little is known about its hydraulic properties. Texas Water Development Board Report 68, 1976, reports that the hydraulic conductivity is between 212 gallons per day per square foot (gpd/ft^2) (0.010 cm/sec) and 272 gpd/ft^2 (0.012 cm/sec). These values are based on a single pumping test performed on a single well. This is the only data available for the Jasper Aquifer near the SDS site. Aquifer heterogeneity may change these values at the SDS site. No close wells are available to obtain confirmation close to the site. 003550

The Burkeville Aquiclude, a continuous, dense, predominantly clay unit, overlies the Jasper Aquifer. An aquiclude is a geologic unit or sequence that transmits water slower than the aquifer above or below it, creating a hydrologic barrier to upward or downward groundwater flow.

The Burkeville Aquiclude, part of the Fleming Formation, averages 320 feet in thickness. The Burkeville Aquiclude crops out north of the project area and dips south. The Burkeville Aquiclude contains several thin sand lenses in the upper part; a few domestic wells produce water from these discontinuous lenses.

The Evangeline Aquifer overlies the Burkeville Aquiclude. The thickness of the Evangeline Aquifer ranges from zero (feet) in northwest Washington County to about 1,840 feet in the southern part of Waller County.

Hydraulic properties of the Evangeline Aquifer were determined from pumping tests made on 25 wells in Austin and Waller Counties. The transmissivity of the Evangeline Aquifer ranged from 7,900 to 99,000 gpd/ft. The hydraulic conductivity ranged from 51 gpd/ft^2 (0.002 cm/sec) to 487 gpd/ft^2 (0.02 cm/sec). The average was 215 gpd/ft^2 (0.01 cm/sec). (Refer to TWDB Report 68.)

Rainfall on the outcrop area furnishes the primary recharge for the area's aquifers. The SDS site is located in the outcrop zone of the Brazos River Alluvium. Site runoff will recharge the alluvium, but there is no direct recharge to underlying aquifers.

The groundwater in the regional aquifers generally flows down dip until it discharges into streams, springs or seeps, or is pumped by wells. Local geologic or geographic conditions may intermittently change this flow pattern.

4.3.1.2 <u>Alluvial Groundwater</u> - The alluvial aquifer is the uppermost aquifer at the SDS site. Previous hydrologic investigations by Texas state agencies indicate that hydraulic characteristics of the Brazos River Alluvium are quite variable and are site specific.

Considering the alluvium of the Brazos River Basin as a hydrogeologic unit, the sequence of deposition generally grades from coarse-grained at the base to fine-grained at the surface. Although the sequence does not change, the relative position of the individual layers and their grain size varies laterally and vertically due to its complex, sedimentological history.

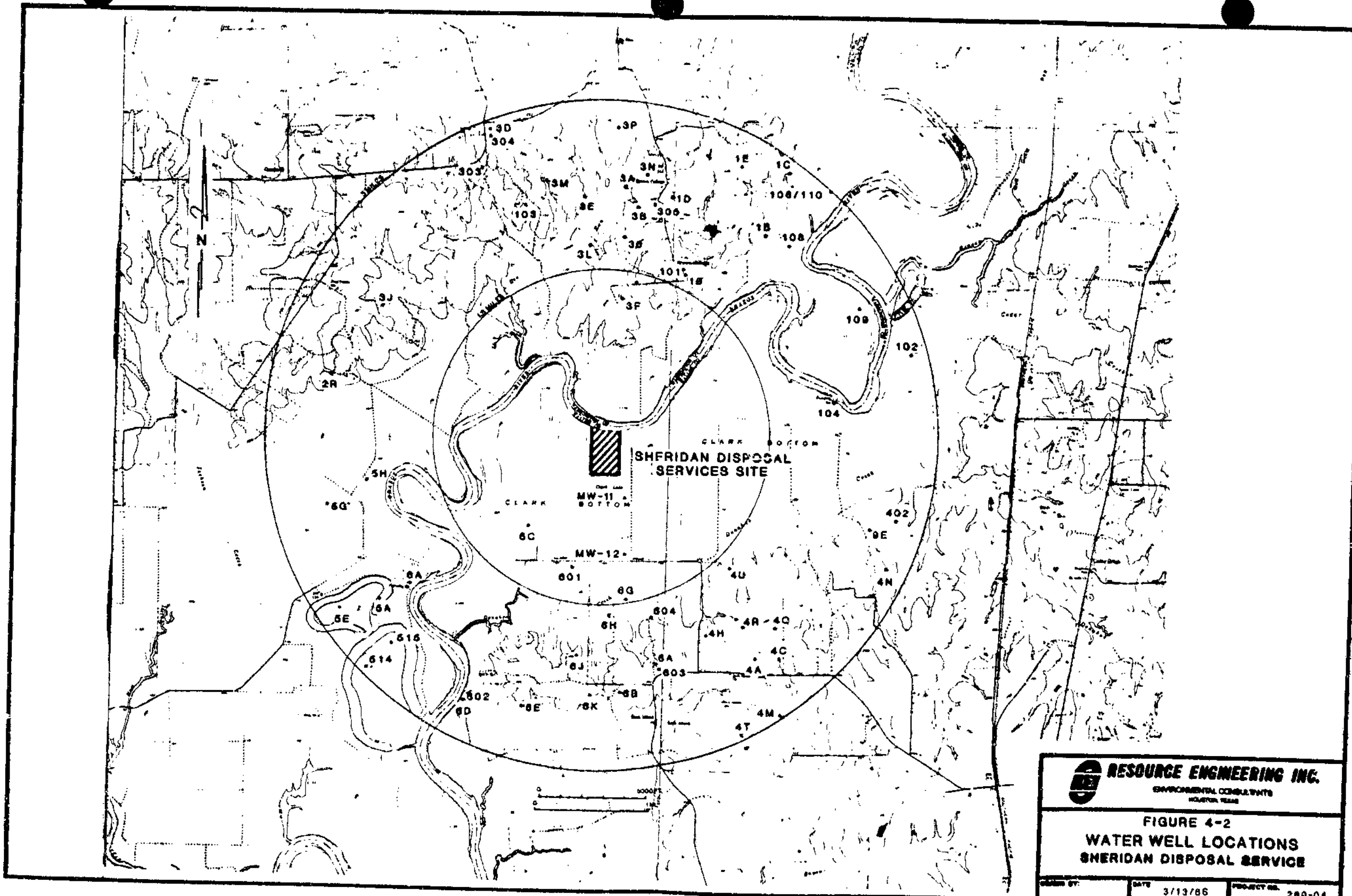
The thickness of the alluvium ranges from 9 feet in northern parts of the Brazos River to over 100 feet near the river's mouth. The average thickness along the river is 45 feet; its thickness at the SDS site is about 55 feet.

Previous investigations by the Texas Water Development Board (TWDB Report 41, "Ground Water in the Flood-Plain Alluvium of the Brazos River, Whitney Dam to Vicinity of Richmond, Texas," 1967) reported calculations for transmissivity, permeability, and storage coefficient of the alluvium using laboratory methods and field pump tests. This is the range of values for the alluvium throughout the entire Brazos River Basin. Transmissivity based on TWDB pumping test data ranged from 50,000 to over 300,000 gpd/ft. TWDB laboratory permeability tests ranged from 0.001 to 18,000 gpd/ft (4.7×10^{-8} to 0.85 cm/sec). This is a very wide range of permeabilities because of the wide range of material tested. The lowest permeabilities occur in tight clays; the highest occur in clean, coarse gravels.

The alluvium is not widely used as a water supply in the immediate area of the SDS site. Water supply wells in this area are usually unreliable because of the variable thickness, transmissivity, hydraulic conductivity and restricted areal extent of the alluvium. Based on site specific pumping test data, the alluvium at the SDS site has a specific capacity of 0.12 gpm/ft. This specific capacity would only support a 2 gpm well at the SDS site based on a saturated thickness of 24'.

Groundwater elevations in the alluvium are generally at or slightly above the elevation of the Brazos River. Groundwater discharges from the alluvium into the Brazos River during base, or low, flow. The river is classed as an effluent, or gaining, stream. During high river flows, however, water temporarily flows from the river into the alluvium. When river flows decrease, water from the alluvium will again discharge into the river.

4.3.1.3 <u>Groundwater Uses</u> - Groundwater is the major source of water for municipal, industrial, domestic and irrigation use in Austin and Waller counties. REI conducted a survey to locate domestic, industrial, municipal and irrigation water wells within a three-mile radius of the site. Location of these wells is shown in Figure 4-2; details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SHERIDAN DISPOSAL
SERVICES SITE
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MW-11
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RESOURCE ENGINEERING INC.
FIGURE 4-2
WATER WELL LOCATIONS
SHERIDAN DISPOSAL SERVICE
3/13/86
269-04

Table 4-2

Description of Water Wells Located Within a
Three-Mile Radius of the Sheridan Disposal Site

Located Well Data

Well No.	Use	Diameter of Well (inches)	Total Depth (ft)	Screened Interval (ft) (depth below ground surface)
101	Domestic	39-42	20.5	20.5
102	Irrigation	14	73	60
103	Stock	5	1049	1029-1049
104	Stock	3.5	400	--
106	Irrigation	16	71	71
108	Stock	4	900	--
109	Stock	4	900	--
110	Irrigation	16	951	--
303	Domestic	6	438	428-438
304	Unused	6	65	46-65
305	Unused	36	46	--
402	Unused	24	50	--
514	Stock	6	65	--
515	Stock	2.5	365	--
601	--	--	--	--
602	Stock	6	396	356-396
603	--	--	--	--
604	Stock	3	178	--

-- No log available

Note: Wells located by TDWR.

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Table 4-3

Plotted Well Data

Well No.	Use	Diameter of Well (inches)	Total Depth (ft)	Screened Interval (ft) (depth below ground surface)
1B	--	--	--	--
1C	--	--	--	--
1D	--	--	--	--
1E	--	--	--	--
1O	--	--	--	--
3A-1	Domestic	4	161	146-161
3A-2	Domestic	4	148	127-148
3B-1	Domestic	4	138	112-138
3B-2	Domestic	4	134	111-134
3D	Domestic	4	161	140-161
3E-1	Domestic	4	360	345-360
3E-2	Domestic	4	253	211-253
3F	Domestic	4	137	116-137
3L-1	--	4	132	111-132
3L-2	Domestic	4	140	--
3M	Domestic	4	181	161-181
3N	Domestic	4	167	152-167
3O	--	--	--	--
3P	Domestic	4	178	163-178
6G	Industrial	4	294	--
6H	Industrial	4	265	--
6J	Industrial	4	262	--
6K	Industrial	4	210	--
4A-1	Farm	4	276	270-276
4A-2	Domestic	4	301	291-301
4C	Irrigation	--	200	165-200
4Q	Industrial	4	210	168-210
4H-1	Domestic	2	115	109-115
4H-2	Domestic	4	106	--
4H-3	Domestic	4	306	296-306
4H-4	Domestic	4	306	296-306
4R	Domestic	4	120	--
4U	--	--	--	--
4T	--	--	--	--
4M-1	--	4	141	120-141

-- No log available

Note: Well locations based on driller log.

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Table 4-3 (Continued)

Plotted Well Data

Well No.	Use	Diameter of Well (inches)	Total Depth (ft)	Screened Interval (ft) (depth below ground surface)
4M-2	Domestic	4	141	136-141
4N	Domestic	2	153	126-153
9E-1	Domestic	4	258	248-258
9E-2	Domestic	4	268	258-268
9E-3	--	--	--	--
9E-4	--	--	--	--
3J	Domestic	2.5	178	163-178
2R	Domestic	4	164	149-164
5H	Industrial	4	210	170-210
5G-1	Industrial	4	210	147-168 189-210
5G-2	Irrigation	12 3/4	130	39-58; 71-76; 79-95; 98-104
5A (Waller)*	Domestic	2	360	340-360
6A-1 (Waller)*	Ranch	4	136	130-136
6A-2 (Washington)*	Domestic	4	203	188-203
6A-1 (Washington)*	Industrial	4	215	180-215
6A-2 (Washington)*	Industrial	4	252	189-210 231-252
6A-3 (Washington)*	Industrial	4	210	168-210
6A-4	Industrial	4	210	168-210
6B-1	Domestic	4	133	127-133
6B-2	Domestic	2	159	153-159
6C	Domestic	4	180	170-180
6D	Industrial	4	249	207-249
6E	Industrial	4	273	231-273
5E	Industrial	4	231	189-231
MW-11	Domestic	-	135	--

-- No log available
* County in which well is located.

Table 4-4

Description of Water Wells Located Downstream or Down Dip and Within a Three-mile Radius of the SDS Site.

Well Number	Total Depth (ft)	Screened Interval (ft)
5H	210	170-210
5E	231	189-231
5A	360	340-360
514	65	--
515	365	--
6C	180	170-180
601	--	--
6G	294	--
6H	265	--
6J	262	--
602	396	356-396
6D	249	207-249
6E	273	231-273
6K	210	--
603	--	--
6A (Waller County)	136	130-136
604	178	--
4U	--	--
4R	120	--
4Q	210	168-210
4C	200	165-200
4T	--	--
5G-1	210	147-210
5G-2	130	39-104
6A-1 (Washington County)	215	180-215
6A-2 (Washington County)	252	189-252
6A-3 (Washington County)	210	168-210
6A-4 (Washington County)	210	168-210
6B-1	133	127-133
6B-2	159	153-159
4A-1	276	270-276
4A-2	301	291-301
4H-1	115	109-115
4H-2	106	--
4H-3	306	296-306
4H-4	306	296-306
4M-1	141	120-141
4M-2	141	136-141
Well 11	135	--

-- No log available

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of the wells are shown in Tables 4-2, 4-3, and 4-4. Table 4-2 lists located well data. Located wells were inspected by Texas Department of Water Resources (TDWR) personnel to determine the well's exact location. Table 4-3 lists plotted well data. Plotted wells were not inspected by state agencies; their locations are based on locations given by drillers to the TWDB. Table 4-4 lists wells within a three-mile radius of the site that are either down-dip or downstream of the site. Tables 4-2 and 4-3 show most of the wells are for domestic or industrial use.

Wells not listed in Table 4-4 are up-dip of the site and are not impacted by the site. Additionally, most of these wells screened deeper than the aquifers at the SDS site.

Based on the elevations shown in Figure 4-2, the screened intervals in Table 4-4, and assuming the beds at the SDS site follow regional patterns and dip to the southeast, then well numbers 5H, 5E, 5A, 5I5, 6O2, 6C, 6D, 5G-1, 6A-1, 6A-2, 6A-3, 6A-4, 4H-3 and 4H-4 in Table 4-4 are likely screened too deep to be impacted by any contamination in the two aquifers of concern at the site.

Wells 514 and 5G-2 are isolated from the SDS site by the river which forms a hydraulic barrier. The remaining wells listed in Table 4-4 are screened in potentially the same aquifers as those underlying the site. However, these wells are all more than 1 mile from the SDS site.

4.3.1.4 Regional Groundwater Quality

The state has monitored groundwater quality in the three regional aquifers: the Jasper Aquifer, Evangeline Aquifer, and Brazos River Alluvium. The water quality of the Jasper Aquifer is marginal for public water supply. Wells that penetrate the upper part of the Jasper Aquifer yield good quality water. However, in wells deeper than 700 feet, the concentrations of iron and total dissolved solids (TDS) may increase to levels above the U.S. Public Health Service recommended limit of 500 mg/l for TDS.

Groundwater from the Evangeline Aquifer generally meets all drinking water standards. Dissolved solids increase slightly with depth, but usually do not exceed the standards. The water is hard, but suitable for most industrial purposes.

Water from the Brazos River Alluvium is of lower quality than water from the upper Jasper Aquifer. TDS concentrations are higher, but usually within recommended limits. Iron concentrations are elevated; hardness ranges from moderately hard to very hard.

4.3.2 Surface Water

4.3.2.1 Brazos River - The Brazos River is the area's dominant surface water feature. The headwaters of the Brazos River originate in eastern New Mexico and the panhandle of Texas. The Brazos flows southeast and discharges into the Gulf of Mexico near Freeport, Texas. A mature river,

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the Brazos meanders across its floodplain, as evidenced by many meander scars and oxbow lakes along its course.

The U.S. Geological Survey (USGS) operates two recording stations on the Brazos River near the project site. The Washington station, number 08110200, is located approximately 21 miles upstream of the site near Washington, Texas. The station has operated since 1965. The drainage area at this station is 41,192 square miles. Its average flow is 5,291 cubic feet per second (cfs). The maximum discharge on record is 82,500 cfs on 1/24/68. The minimum discharge was 170 cfs on 10/22/78. On 10/1/85 the USGS stopped recording flow at this station and currently uses it to record only water stage heights.

The second station, number 08111500, is located approximately 14 miles downstream of the SDS site near Hempstead, Texas. This station has operated since 1938. The drainage area is 43,880 square miles at this station, and has an average discharge of 6,627 cfs. The maximum discharge on record is 143,000 cfs on 5/2/57; the minimum discharge was 137 cfs on 11/6/52.

Two major tributaries to the Brazos River lie between these two recording stations. The Navasota River discharges into the Brazos River between the Washington station and the SDS site. The Hempstead station records its contribution. New Year Creek is the largest stream that discharges into the Brazos River between the SDS site and the

Hempstead station. New Year Creek is an intermittent creek that has a drainage area of approximately 230 square miles. New Year Creek represents approximatley 0.5% of the Brazos River drainage basin and makes an insignificant flow contribution to the Brazos River at the Hempstead station.

4.3.2.2 Local Surface Water Features - The SDS site is located on a cut bank above the river and slopes away from the river. Most of the overland runoff flows south, away from the river, into Clark Lake. However, there is a small component of runoff that flows west into a local ditch, and then into Clark Lake. Clark Lake, a shallow lake created by two man mode dams, may be a remnant oxbow of the Brazos River. Clark Lake discharges into a drainage ditch that flows southwest into Donahoe Creek during high water stage on Clark Lake. Clark Lake begins to discharge when the water surface elevation is approximately 161 feet MSL.

Donahoe Creek is a small intermittent creek located south of the site (Figure 5-3). It flows to the west and discharges into the Brazos River approximately five miles downstream from the site.

Several small stock-watering ponds and marshes occur in the area. Chapter 5 addresses surface water hydrology of the site in more detail.

4.4 Site Geology and Soils

4.4.1 Geology - The SDS site is located on the alluvium of the Brazos River. The Brazos River Alluvium blankets the Fleming Formation at the site. Twenty monitor wells, 9 borings and 20 cone penetrometer soundings were used to assess the geologic setting. Their locations are shown on Figure 4-3.

Cone penetrometer soundings consist of pushing a cone-tipped probe into a soil deposit. While the probe is advanced, a continuous record of cone tip and side friction resistance versus depth is obtained in both analog and digital form. A computer program calculates friction ratio (friction resistance divided by cone resistance, in percent) versus depth. The friction ratio is correlated to nearby boreholes which have been continuously logged. After the friction ratio has been correlated, cone penetrometer soundings can be used to map stratigraphy. Cone penetrometer data at the SDS site were correlated to boreholes C-7/MW-13, C-9/MW-15, C-8/MW-14, C-1/MW-7, C-11/MW-16, C-12/MW-17. Cone penetrometer soundings are shown in Appendix 4A.

The monitor wells and borings installed by REI were drilled using hollow stem auger and mud rotary methods. Shallow holes, generally less than 30 feet, were drilled using hollow stem augers. Deeper holes were drilled with mud rotary (Appendix 4A). Mud rotary methods generally used potable water as the drilling fluid to form natural mud.

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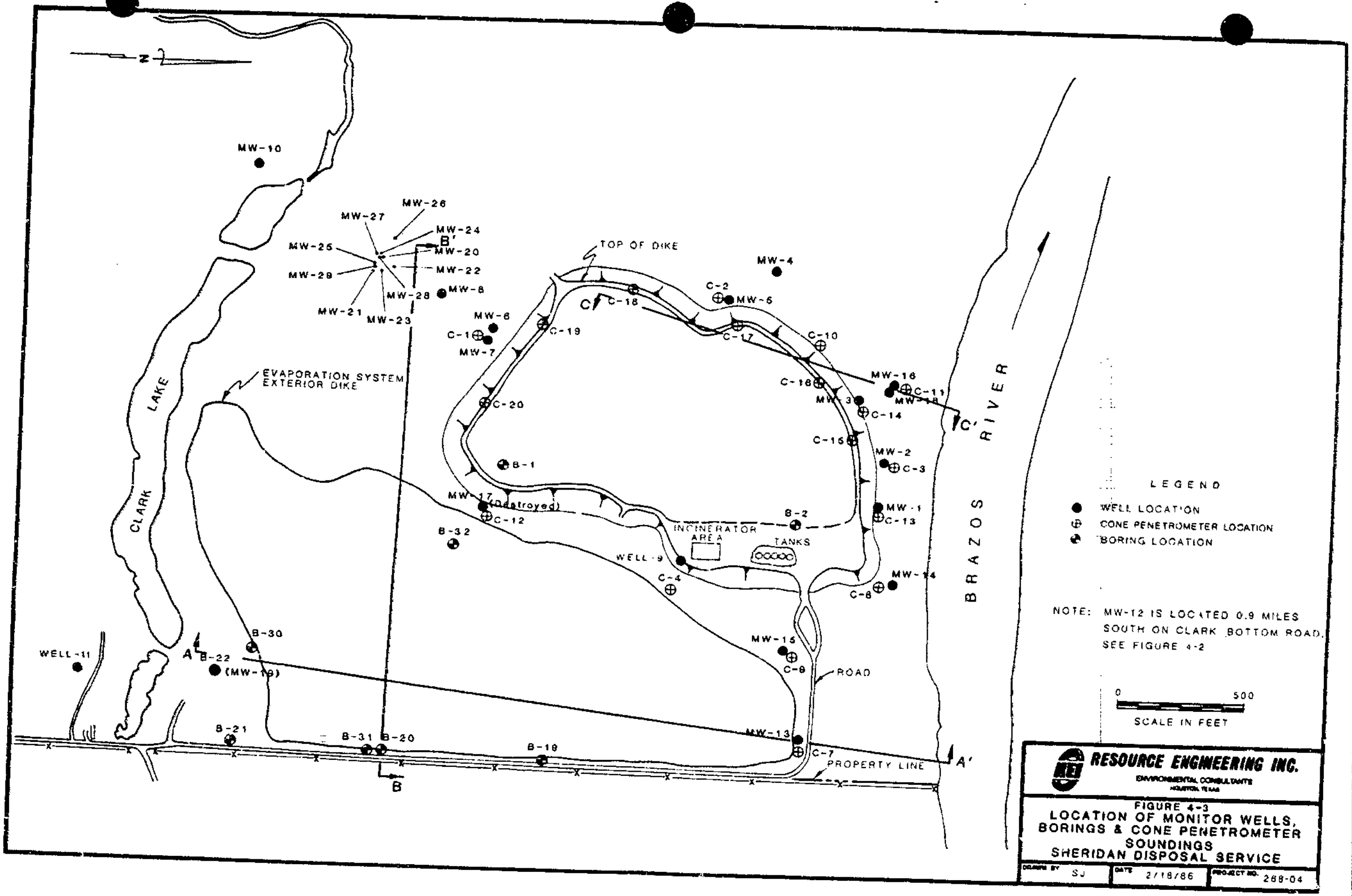

FIGURE 4-3
LOCATION OF MONITOR WELLS, BORINGS & CONE PENETROMETER SOUNDINGS
SHERIDAN DISPOSAL SERVICE

Occasionally, powdered bentonite was added to thicken the mud to prevent the hole from collapsing while installing protective surface casing. It is unclear that all monitoring wells at the site have been adequately developed after installation. Details on well development are given in Appendix 4C.

Samples were collected using Shelby tubes or split spoon samplers. The samples were visually logged on site by a hydrogeologist. Selected samples were analyzed in the REI soils laboratory for particle size distribution, sieve analysis, and Atterberg limits. The logs of the monitor wells, borings, cone penetrometer strip charts, and laboratory results are presented in Appendix 4A.

Data from all subsurface investigations were used to assess the site geology. In general, REI identified five stratigraphic units at the site (Stratums A, B, C, D and E), which are shown schematically on Figure 4-4. Detailed cross-sections of these units based on REI field data, are shown in Figures 4-5, 4-6, and 4-7.

Strata A and B, subunits of the alluvium, are not mapped regionally. These strata are typical of alluvial deposits consisting of unconsolidated sands, silts, and clays. These deposits are interbedded and grade laterally and vertically into finer or coarser material.

The upper 40 feet at the site (Stratum A) consists of interbedded sands, silts, and clays which are shown on three cross-sections: Figures 4-5, 4-6 and 4-7. Figure 4-5

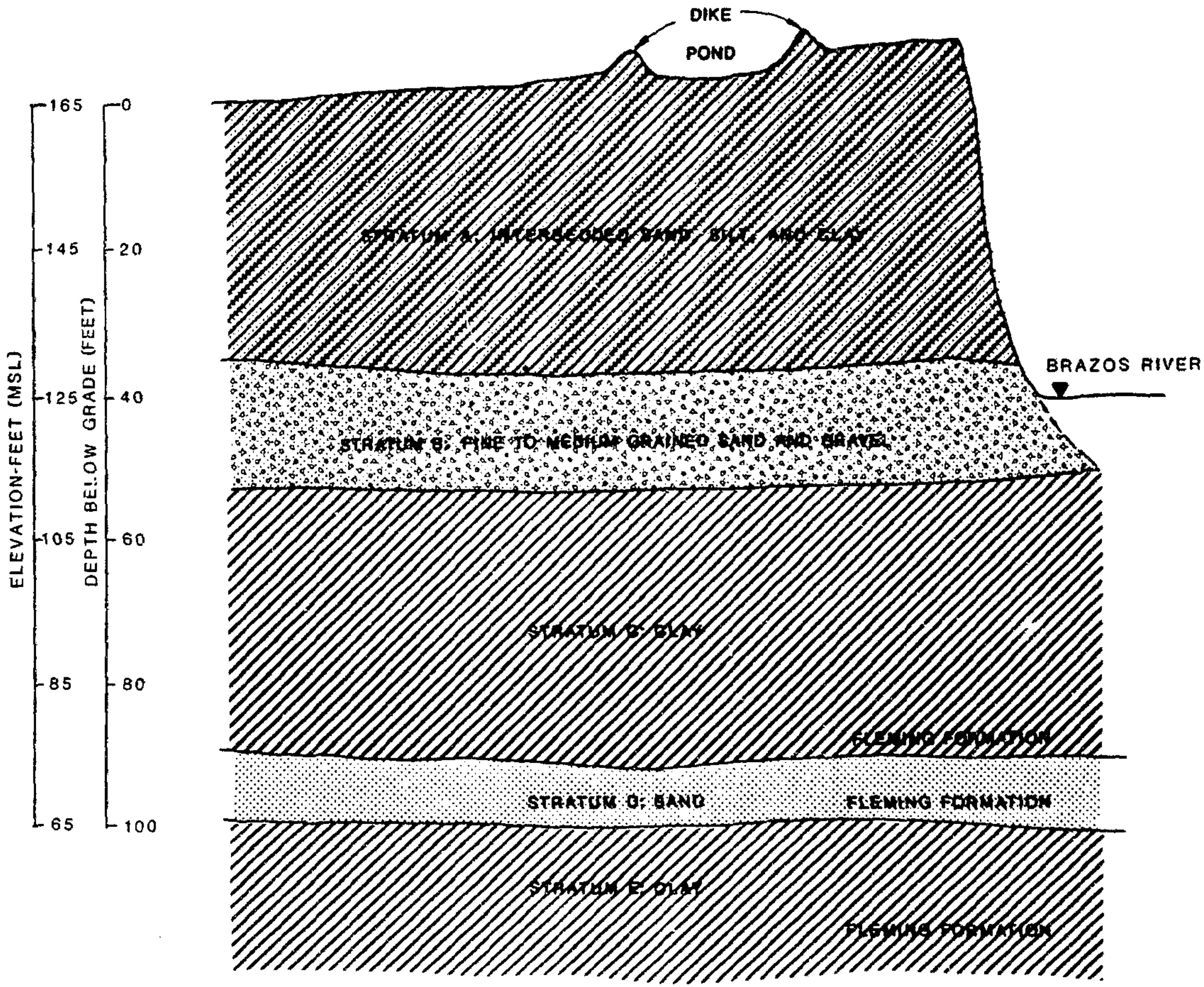

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FIGURE 4-4

GENERAL SCHEMATIC SITE GEOLOGY

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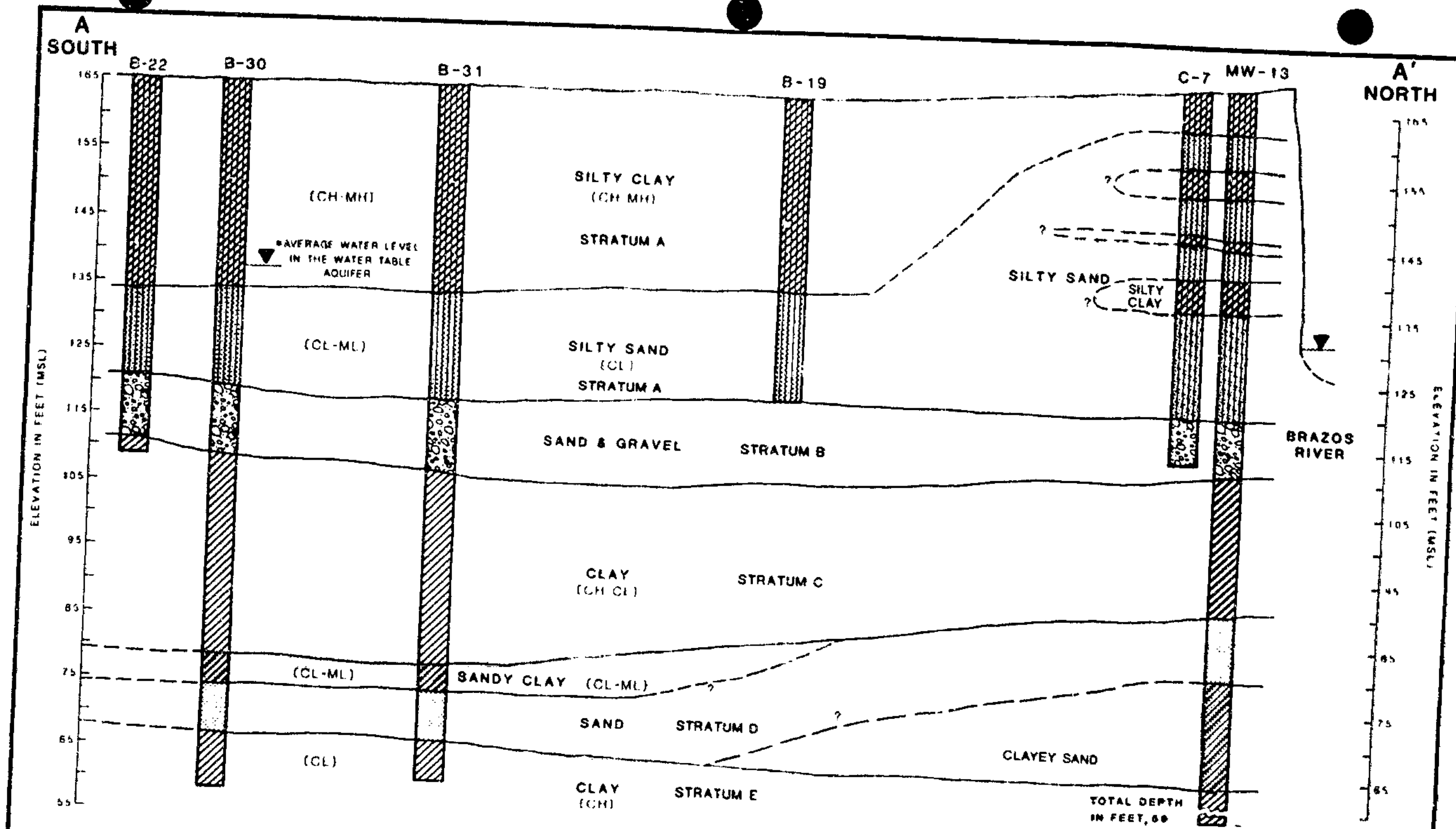

* THE AVERAGE WATER LEVELS REPRESENT THE SITE AVERAGE BASED ON SPATIAL AND TEMPORAL AVERAGES

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FIGURE 4-5
STRATIGRAPHIC CROSS SECTION A-A'
SHERIDAN DISPOSAL SERVICE

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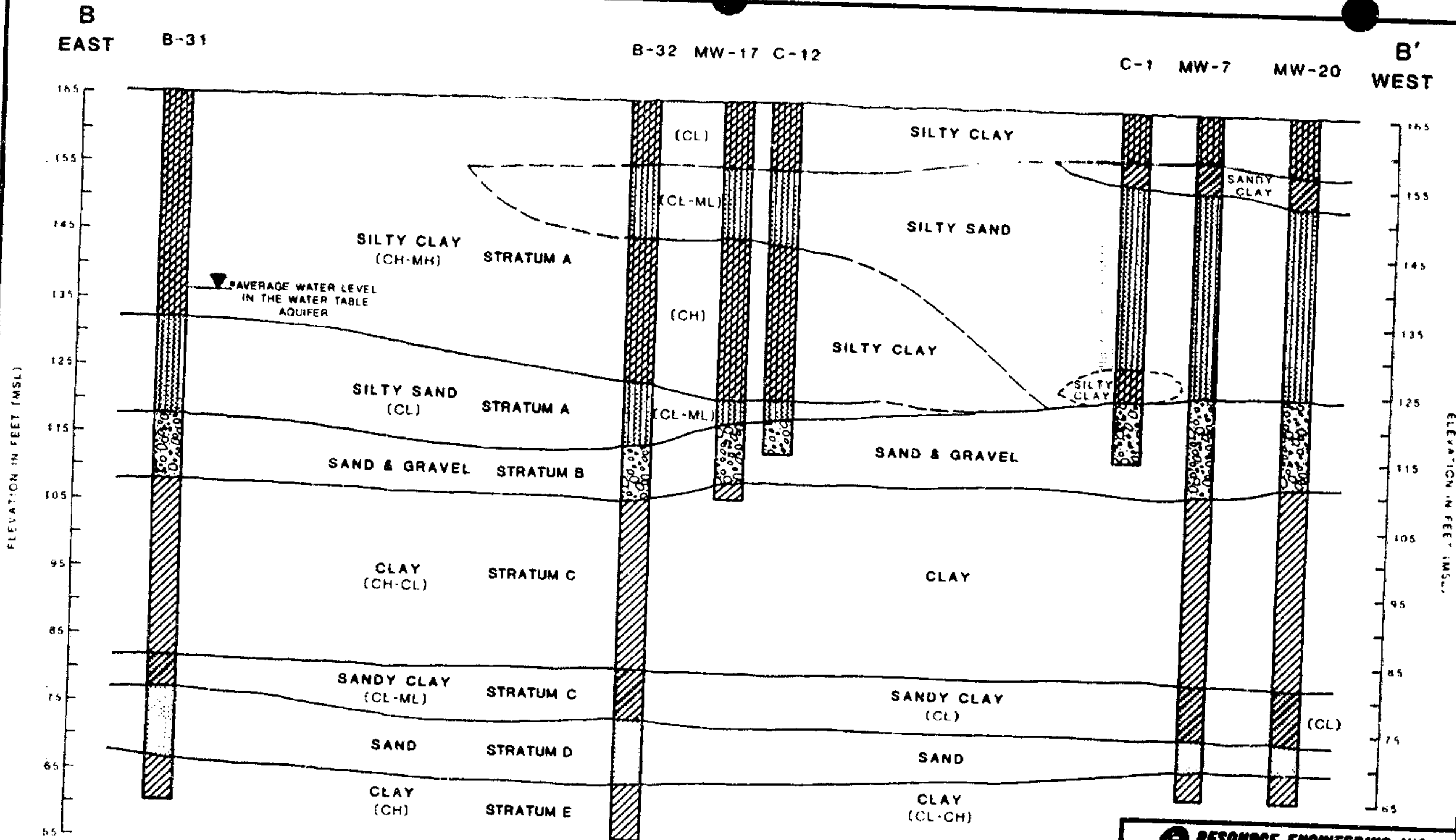
L M G	2-11-86	288-04



* THE AVERAGE WATER LEVELS REPRESENT THE SITE AVERAGE BASED ON SPATIAL AND TEMPORAL AVERAGES

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FIGURE 4-6
STRATIGRAPHIC CROSS SECTION
B-B'
SHERIDAN DISPOSAL SERVICE

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L.M.G.	2-13-86	288-04

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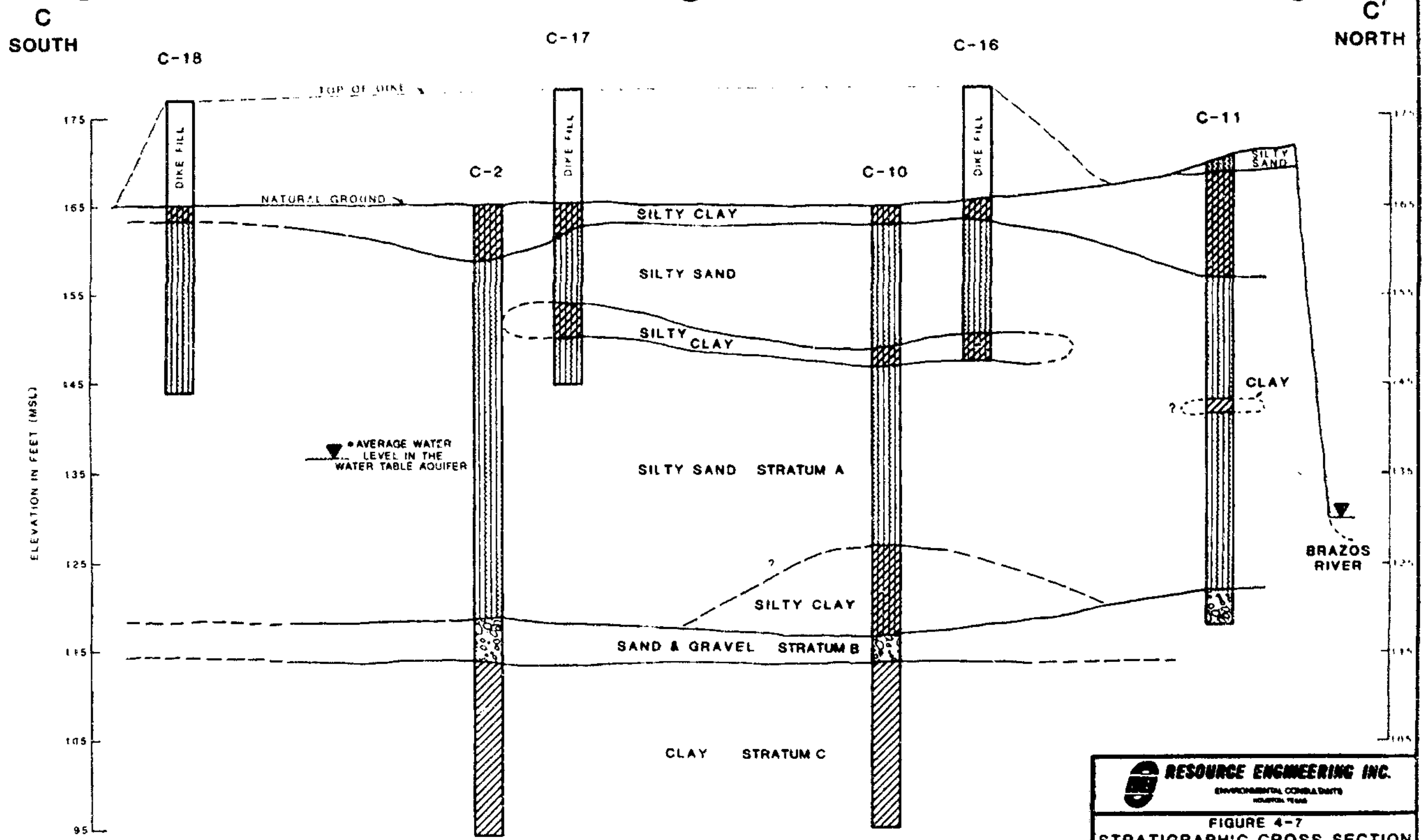

* THE AVERAGE WATER LEVELS REPRESENT THE SITE AVERAGE BASED ON SPATIAL AND TEMPORAL AVERAGES

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FIGURE 4-7
STRATIGRAPHIC CROSS SECTION
C-C'
SHERIDAN DISPOSAL SERVICE

DRAWN BY	DATE	PROJECT NO.
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shows that Stratum A consists of 30 feet of silty clay at the southern part of the site. This silty clay overlies 15 feet of silty sand. The silty clay thins out to 5 to 10 feet thick to the north, while the silty sand thickens to 35 feet. Figure 4-6 (cross-section B-B') shows that the site's eastern part is situated on a silty clay approximately 30 feet thick. This silty clay pinches out and grades into a silty sand toward the west. The silty sand subunit is observed within Stratum A over the western part of the site; it ranges in thickness from about 20 to 35 feet. Stratum A consists of a thin silty clay layer near the river, overlying interbedded silty sands and clays.

Stratum B is a continuous sand layer, fairly uniform throughout the site. The fine to medium grained sand contains thin silt and clay seams. Stratum B, approximately 40 feet below grade, averages 15 feet in thickness. Gravel is interbedded with the sand in the lower part of Stratum B. Most is round to subangular; some is angular. Gravel diameters range from 0.25 to over 2 inches; colors range from white to pink and dark grey consisting of quartz and feldspars. The gravel is poorly sorted and interbedded with sand, silts, and clays.

Stratum C, a dense clay layer, is located approximately 55 feet below grade, with an average thickness of 35 feet. This stratum is uniform and continuous throughout the

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site. The clay becomes sandier with depth and grades into a sandy clay throughout the lower 10 feet. Stratum C is the first expression of the Fleming Formation beneath the site.

Stratum D is a sand layer located 90 feet below grade at the site. This sand layer averages 10 to 12 feet in thickness and consists of fine to medium grained sand. There are silt and clay seams interbedded within the sand. Stratum D is also part of the Fleming Formation.

Stratum E is a dense clay layer found approximately 90 feet below grade. Stratum E is part of the Fleming Formation. Stratum E is the deepest unit addressed beneath the site.

4.4.2 Soils - The SDS site is located on soils of the Brazoria-Norwood Association. This association consists of soils on broad floodplains along the Brazos River. The soils are level to gently sloping, somewhat poorly drained to well drained, and clayey to loamy soils. There are five soil types at the SDS site (Figure 4-8), listed in Table 4-5. Table 4-5 shows the soils' engineering characteristics.

The Brazoria series consists of deep, somewhat poorly drained, clayey soils on the floodplain along the Brazos River. This series formed from thick clayey alluvial sediment. The soil, typically 80 inches deep, is dark reddish-brown clay that is calcareous throughout. The soil series is divided based on percent slope.

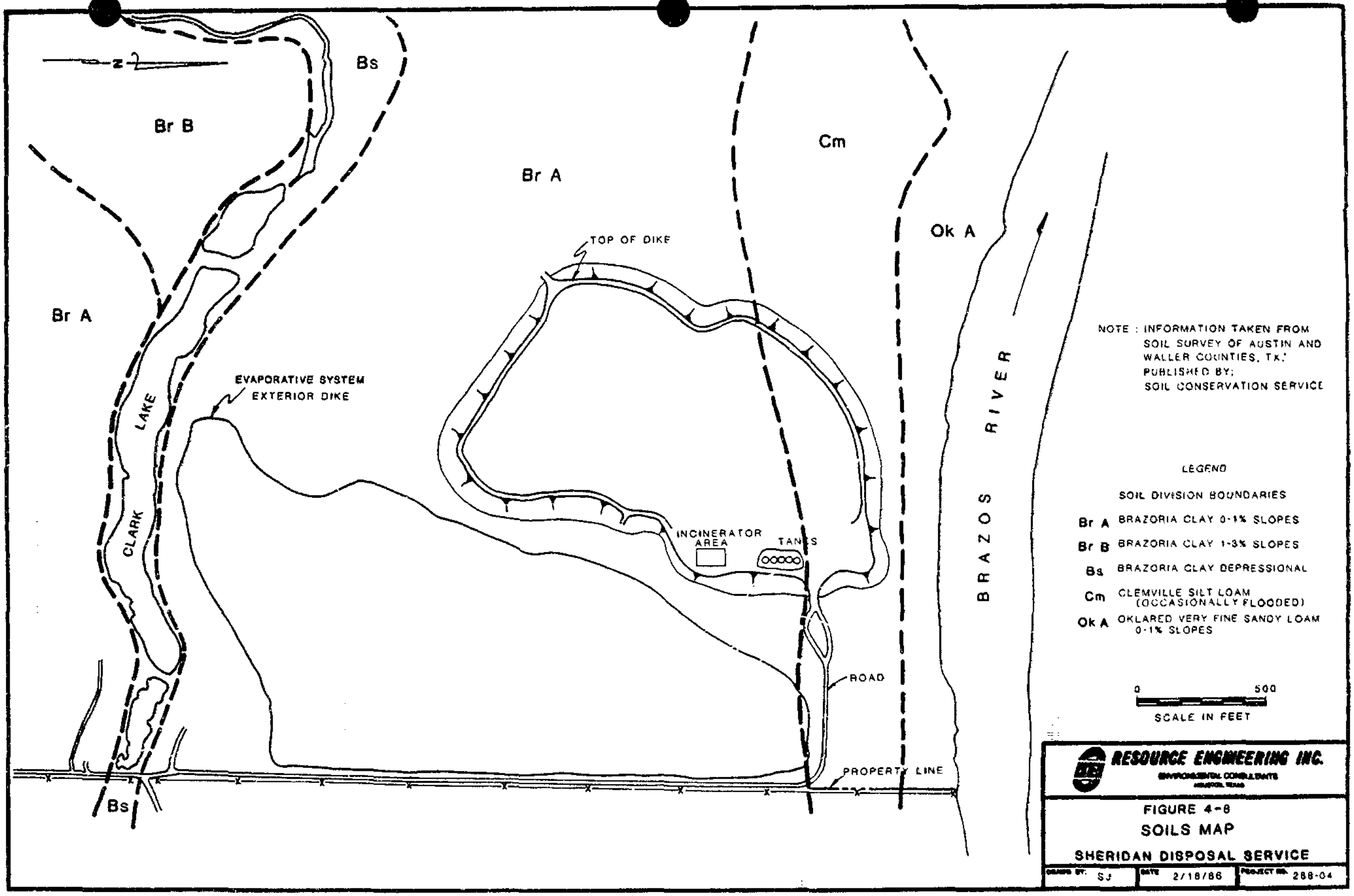
N
Br B
Bs
Br A
Cm
Ok A
Br A
TOP OF DIKE
EVAPORATIVE SYSTEM EXTERIOR DIKE
CLARK LAKE
INCINERATOR AREA
TANKS
ROAD
PROPERTY LINE
BRAZOS RIVER
Bs
NOTE : INFORMATION TAKEN FROM SOIL SURVEY OF AUSTIN AND WALLER COUNTIES, TX.' PUBLISHED BY: SOIL CONSERVATION SERVICE
LEGEND
SOIL DIVISION BOUNDARIES
Br A BRAZORIA CLAY 0-1% SLOPES
Br B BRAZORIA CLAY 1-3% SLOPES
Bs BRAZORIA CLAY DEPRESSIONAL
Cm CLEMVILLE SILT LOAM (OCCASIONALLY FLOODED)
Ok A OKLARED VERY FINE SANDY LOAM 0-1% SLOPES
0 500
SCALE IN FEET
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FIGURE 4-8
SOILS MAP
SHERIDAN DISPOSAL SERVICE
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2/18/86
288-04

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Table 4-5

Soil Types and Their Engineering Characteristics

Soil Type	Depth (in)	Percent Passing 200 sieve	Unified Soil Class	Permeability (cm/sec)	Hydraulic Soil Group	pH
Brazoria Clay 0-1% slope (BrA)	0-80	95-100	CH	<0.00004	D	7.4-8.4
Brazoria Clay 1-3% slope (BrB)	0-60	95-100	CH	<0.00004	D	7.4-8.4
Brazoria Clay depressional (BS)	0-60	95-100	CH	<0.0004	D	7.4-8.4
Clemville Silt Loam (Cm)	0-20	70-95	CL, CL-ML	0.0001-.0004	B	7.9-8.4
Oklared (OKA)	0-80	51-85	CL, ML, CL-ML	0.001-0.004	B	7.4-8.4

Source: SCS Soil Survey of Austin and Waller Counties Texas.

The Clemville series consists of deep, well drained, loamy soils on floodplains. The soil is usually reddish-brown, silty loam to about 25 inches, grading into a dark, reddish-brown clay to about 60 inches. The soil is moderately alkaline and calcareous throughout.

The Oklared series is deep, nearly level soil on floodplains. The surface layer is brown, very fine sandy loam, about eight inches thick. This grades into a light brown, fine sandy loam 60 inches deep with sandy loam and loamy fine sand strata throughout.

The Brazoria-Norwood Association basically consists of clayey to loamy soils. The hydraulic soil group for each soil type is shown in Table 4-5. The hydraulic soil group is a factor used to calculate surface runoff. The "D Group" contains soils that swell significantly when wet, or heavy plastic clays. Most of the soils at the southern part of the site are "D Group." This type of soil restricts the infiltration of rainwater and limits the amount of groundwater recharge.

The northern part of the SDS site is located on the Clemville Silt Loam and the Oklared Very Fine Sand Loam Soils. Both these soils are clayey to loamy and are in hydraulic soil "Group B." "B Group" soils have a moderate infiltration rate when thoroughly wetted. This infiltration rate generally applies to the top five feet of the soil. Borings and cone penetrometer data indicate a clay layer

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extends deeper than five feet. This clay layer will restrict the movement and infiltration of groundwater.

4.5 Site Groundwater - Groundwater exists in nature under two conditions: water table or confined (artesian). Water table conditions occur when the groundwater surface is under atmospheric pressure and the water level is free to change with the changes in the volume of water stored. Confined conditions occur when permeable materials are overlain and underlain by less permeable material. Water levels in a confined aquifer will rise above the base of the confining bed, when penetrated by a well or other opening.

Both unconfined (water table) and confined aquifers are present at the SDS site. The water table aquifer is the first aquifer encountered below ground surface and consists of Strata A and B. The confined aquifer (Stratum D), beneath the water table aquifer, is separated from it by a 35-foot confining, clay layer (Stratum C). The two aquifers are shown on Figure 4-9, and are further described as follows:

4.5.1 Water Table Aquifer - A total of 17 monitor wells have been installed at the SDS site in the water table aquifer by various organizations during the past 14 years. The first wells, MW-4 and MW-8, were installed in 1972 to monitor the aquifer and comply with regulatory requirements in the SDS site's waste disposal permit. In 1983, an EPA field

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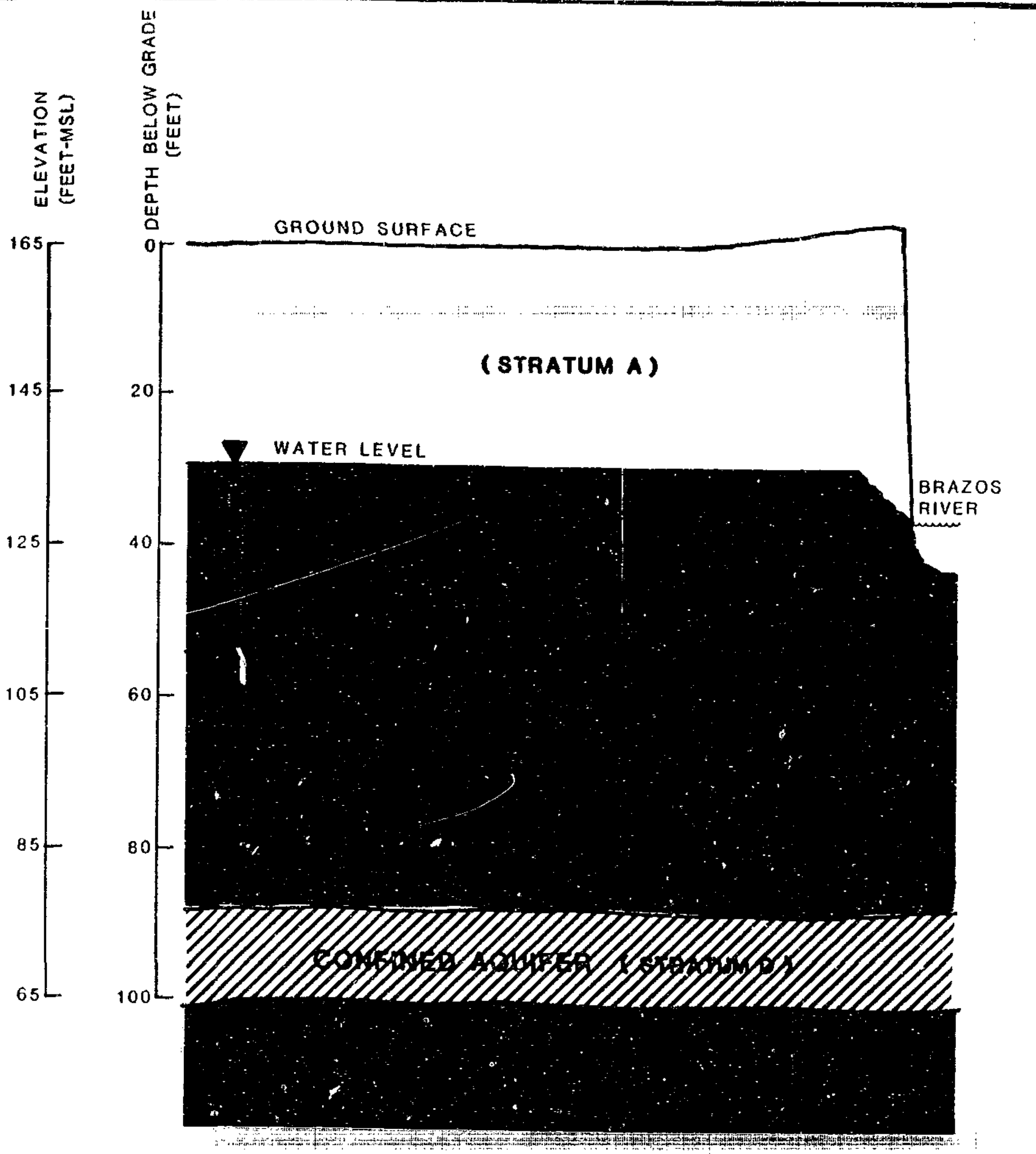

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FIGURE 4-9

SCHEMATIC OF THE TWO AQUIFERS AT THE SHERIDAN DISPOSAL SERVICE SITE

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investigation team installed 3 additional wells, MW-1, MW-3 and MW-6 to assess the impact of disposal operations on the water table aquifer. Since 1984, REI has installed 12 additional wells to investigate and monitor the water table aquifer. The locations of all 17 wells are shown on Figure 4-10; details of well completions are presented in Table 4-6 and shown in Appendix 4B. Additional wells will be added to characterize the aquifer as part of the Groundwater Migration Management R.I.

4.5.1.1 Hydraulic Characteristics - One fully penetrating well (MW-29) and four piezometers (MW-21, 23, 24, 25) were installed to conduct a pump test for determining the aquifer characteristics of the water table aquifer (Strata A and B). The REI "Hydrogeologic Investigation Plan" (HIP), submitted in August of 1985 and approved by the EPA, detailed the procedures. Several minor changes of well locations were made in the field which differ from those shown in the HIP. The changes were made to improve the installation procedures. Construction details of these monitor wells are described in Appendix 4B. Development procedures are discussed in Appendix 4C.

A pump test was conducted using an electric submersible pump and electric sounders to measure the water level in the piezometers. The discharged water was containerized and disposed of in the SDS pond.

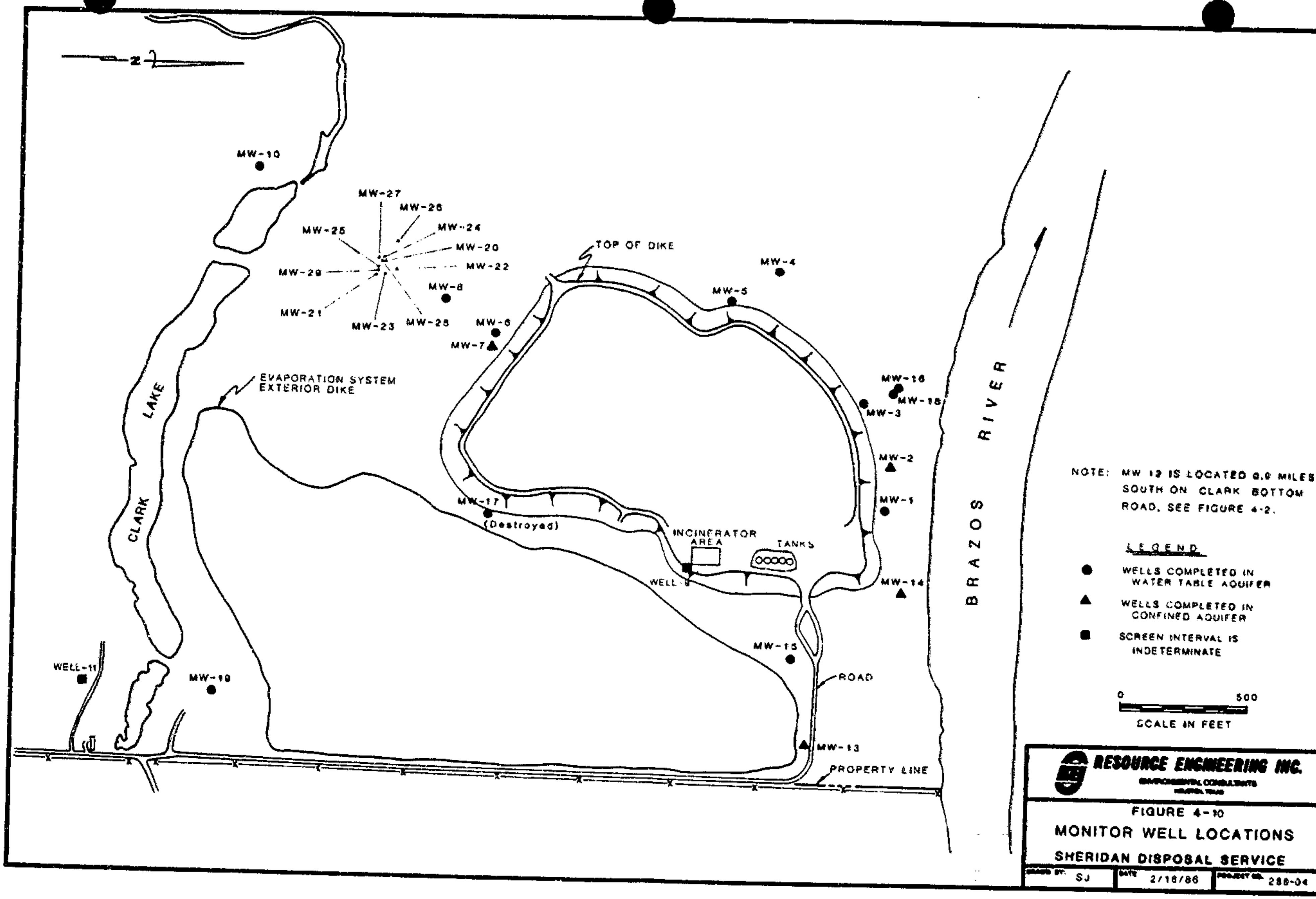

FIGURE 4-10
MONITOR WELL LOCATIONS

Table 4-6

Details of Monitor Well Construction

Well Number	Total Depth (ft)	Screened Interval (ft)	Date Installed	Aquifer Monitored*	Description
MW-1	65	50-60	1983	1	EPA FIT Well, No. 3
MW-1**	40.5	NA	1985	1	Resource Engineering
MW-2	114	94-106	1972	2	O'Malley & Clay (north well)
MW-3	65	53-63	1983	1	EPA FIT Well, No. 2
MW-4	69	55-61	1972	1	O'Malley & Clay (west well)
MW-5	60	54-60	1963	1	Old Windmill Well
MW-6	58	43-58	1983	1	EPA FIT Well, No. 1
MW-7	100	80-95	1984	2	Resource Engineering
MW-8	65	51-57	1972	1	O'Malley & Clay (south well)
Well 9	165***	?	1963		Production Well for Boiler
MW-10	44.5	28-43	1984	1	Resource Engineering
Well 11	135***	?	?		Farm House Well
MW-12	40	24-39	1984	1	Resource Engineering
MW-13	93	83-93	1984	2	Resource Engineering
MW-14	102	92-102	1984	2	Resource Engineering
MW-15	61	51-61	1984	1	Resource Engineering
MW-16	61	48-53	1984	1	Resource Engineering
MW-17	Accidentally Destroyed			1	Resource Engineering
MW-18	58.5	32-57	1984	1	Resource Engineering
MW-19	57	34-54	1984	1	Resource Engineering
MW-20	98	85-97.5	1985	2	Resource Engineering
MW-21	54	4-54	1985	1	Resource Engineering
MW-22	101	85-100	1985	2	Resource Engineering
MW-23	54	4-54	1985	1	Resource Engineering
MW-24	54	4-54	1985	1	Resource Engineering
MW-25	54	4-54	1985	1	Resource Engineering
MW-26	98.5	83.5-98.5	1985	2	Resource Engineering
MW-27	102	85-97	1985	2	Resource Engineering
MW-28	98	85.5-98	1985	2	Resource Engineering
MW-29	56	5-55	1985	1	Resource Engineering

*Aquifer Monitored: 1=water table aquifer, 2=confined aquifer
**MW-1 became plugged with silt, it was reconstructed with open ended 1-inch PVC pipe.
***Total depth report by Duane Sheridan, not confirmed

The discharge flow rate during the pump test fluctuated from 1.7 to 1.5 gpm during the first three hours of the test. The discharge rate generally decreased during this time. Fluctuating water levels were created in the piezometers and pump well due to the variable pumping rate. During the last five hours of the test, the discharge rate stabilized at 1.5 gpm.

Time-drawdown curves for the pump well and four piezometers are shown in Appendix 4D. The curves show rapid drawdown in the first 15 minutes of the test. Water levels were steady for an hour but slowly recharged as the pumping rate decreased. After the pumping rate stabilized, the water levels in the piezometers decreased and stabilized. See Appendix 4D for data.

Three methods were used in an attempt to correct the data for variable discharge:

1. the Aron-Scotts method for continuously decreasing discharge;

2. the Cooper-Jacobs step type pumping; and

3. the Theis unsteady-state flow.

None of these methods proved to be successful and the data were analyzed using the following procedures.

Pumping test data were analyzed using Theis curve matching (using the early drawdown data), Jacobs straight line method, and recovery data. The recovery data were analyzed using Theis curve matching at MW-25, the only well monitored during recovery. Theim-Dupuit's method was considered; however, because the data indicated there was no concentric boundary of constant head around the pumping well, all the assumptions were not met and this method was not used. Results are listed in Table 4-7.

Table 4-7 shows the average hydraulic conductivity and transmissivity to be 7.9×10^{-3} cm/sec and 4.0×10^{3} gpd/ft, respectively. The hydraulic conductivity was calculated using an average saturated thickness of 24 feet, based on field measurements made on 12/18/85, the day of the pumping test. The hydraulic conductivity values are within the range of published values for a silty sand. Because of the low hydraulic conductivity, the aquifer would be considered marginal as a source of water.

4.5.1.2 <u>Groundwater Flow</u> - The water table aquifer is in direct hydraulic connection with the Brazos River. Therefore, interpretation of water level measurements must consider the effect of the river stage. The river stage at the SDS site can be approximated by using USGS data, site elevations, river elevation during low flow, and visual observations by a field hydrologist.

The USGS operates a gaging station on the Brazos River near Hempstead, 14 miles downstream of the SDS site, as discussed in Section 4.3.2.1. This station records stage height and discharge. Using stage height

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Table 4-7

SUMMARY OF WATER TABLE AQUIFER CHARACTERISTICS

Method Well Number	Transmissivity (gpd/ft)	Hydraulic Conductivity (cm/sec)
Jacobs		
MW-21	3.3×10^3	6.6×10^{-3}
MW-23	4.2×10^3	8.4×10^{-3}
MW-24	6.2×10^3	1.2×10^{-2}
MW-25	5.4×10^3	1.1×10^{-2}
Theis		
MW-21	2.1×10^3	4.2×10^{-3}
MW-25	3.6×10^3	7.2×10^{-3}
Recovery		
MW-25	2.9×10^3	5.8×10^{-3}
Average	4.0×10^3	7.9×10^{-3}

Revised 1/13/87

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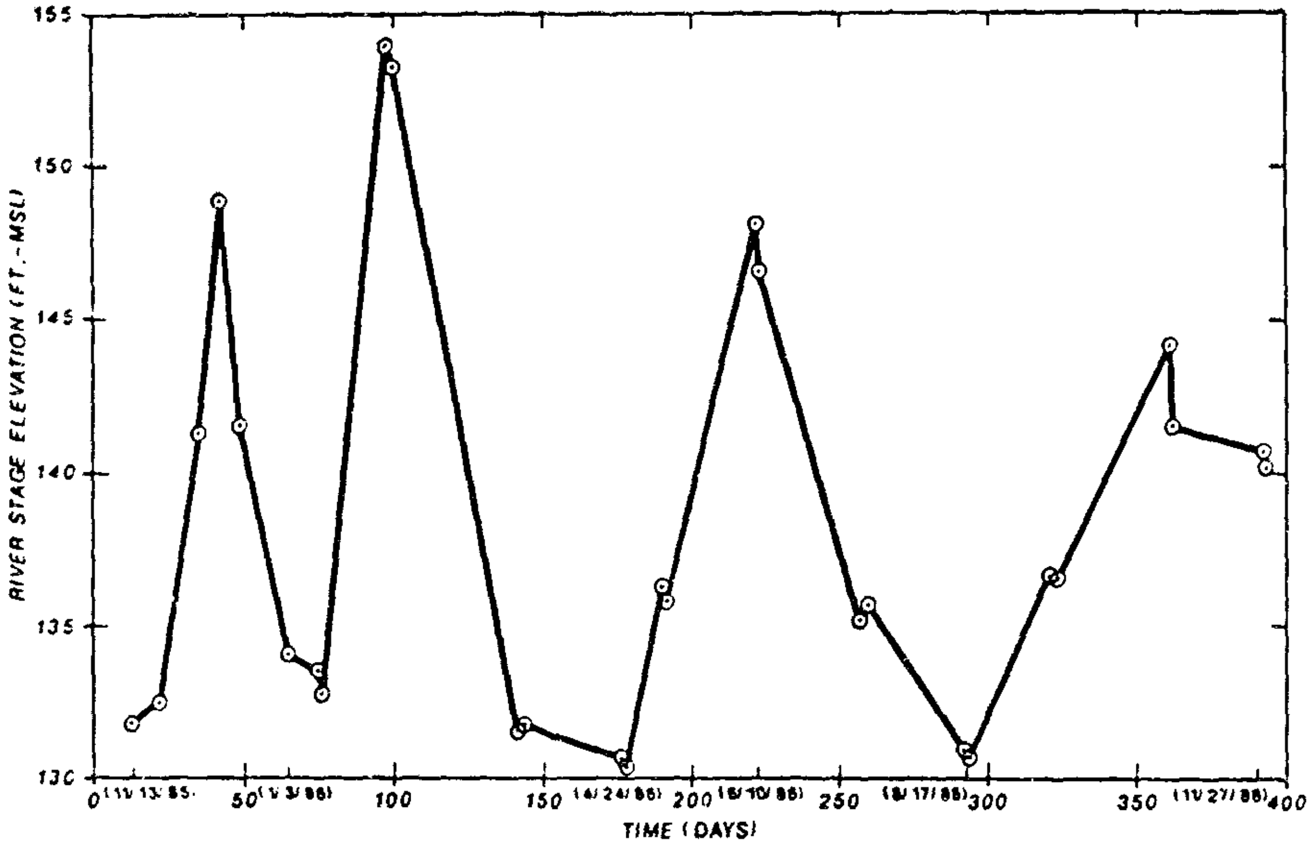
(elevations) at this gaging station and field measurements made at the SDS site during low flow, a correction factor was determined.

On 7/13/84 the surface water elevation at the Hempstead station was 120.5 feet Mean Sea Level (MSL). A licensed survey crew measured the elevation of the river at the SDS site as 129.5 MSL that day. On 11/22/85 at MW-18, the groundwater elevation was 132.9 feet MSL, assuming a 0.5 foot difference between MW-18 and the river based on hydraulic gradient. The surface water elevation at the Hempstead station on 11/22/85 was 122.9 feet MSL. The correction factor at the Hempstead station is 9.5 feet. This factor is approximate and will be refined based on data obtained for the Groundwater Migration Management RI.

Figure 4-11 shows the mean daily stage elevation of the Brazos River at the SDS site during the monitoring period. This figure shows the stage height on the day preceding a water level measurement and on the day the water level measurement was made. Figure 4-11 does not show changes in stage heights which occurred between groundwater level measurements measuring episodes.

Figure 4-11 shows that the Brazos River stage fluctuated widely during the monitoring period. Maximum and minimum river stages were calculated to be 153.9 feet and 130.5 feet MSL, respectively, for the date that water



NOTE. STAGE HEIGHTS HAVE BEEN CORRECTED TO ELEVATIONS AT THE SDS SITE

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FIGURE 4-11

BRAZOS RIVER MEAN DAILY STAGE ELEVATIONS

SHERIDAN DISPOSAL SERVICES

DRAWN BY	DATE	PROJECT NO
RLS	1-16-87	288-04

003584

Table 4-8

Brazos River Gage Heights and Discharges

Date	Discharge (cfs)	Gage Height (ft)	River Elevation at The SDS Site (ft MSL)
11/6/85	3,700	NR	-
11/13/85	2,269	4.45	131.75
11/22/85	2,740	5.05	132.45
12/6/85	14,800	13.90	141.3
12/13/85	36,000	21.5	148.9
12/19/85	15,200	14.1	141.5
1/3/86	4,000	6.65	134.05
1/14/86	3,475	6.10	133.5
1/15/86	2,870	5.41	132.81
2/6/86	47,400	26.54	153.94
2/7/86	45,100	25.83	153.23
3/20/86	2,050	4.15	131.55
3/1/86	2,150	4.29	131.69
4/23/86	1,470	3.26	130.66
4/24/86	1,350	3.06	130.46
5/8/86	6,500	8.85	136.25
5/9/86	5,770	8.25	136.65
6/10/86	29,300	20.69	148.09
6/11/86	25,400	19.17	146.57
7/14/86	5,300	7.70	135.10
7/15/86	5,960	8.29	135.69
8/17/86	1,650	3.55	130.95
8/18/86	1,540	3.37	130.77
7/17/86	7,250	9.20	136.60
9/18/86	7,190	9.15	136.55
10/26/86	20,700	16.68	144.08
10/27/86	15,200	14.08	141.48
11/27/86	13,700	13.30	140.70
11/28/86	12,700	12.75	140.15
1/2/87	NA	NA	NA

Source: Preliminary USGS Data

Revised 1/13/87

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level measurements were made. River stage height and discharge values at the Hempstead gaging station are listed in Table 4-8.

Water levels in the water table aquifer fluctuate with the Brazos River stage. However, the groundwater-level fluctuations are less then the river stage fluctuations. The range of water level elevations is summarized in Table 4-9. Water level measurements for all the monitoring wells are shown in Attachment 4E.

The relationship between river stage elevation and groundwater level fluctuations is shown in Figure 4-12. Figure 4-12 compares river stage elevation with water elevations at wells MW-1 and MW-6. The groundwater level fluctuations mirror the river stage fluctuations. The effects of the river on groundwater levels is dependent on the distance from the river. This relationship is shown in Table 4-9.

Table 4-9 shows the magnitude of change in groundwater-level elevation at a point over the monitoring period depends on the distance from the river. Wells MW-1, MW-16, and MW-18 are about 200 feet from the river and their water level fluctuated about 9.5, 8.3 and 8.5 feet, respectively. As well distance from the river increases, the water-level fluctuations range decreases. Well MW-6 (about

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Table 4-9

Range of Water-Level Elevations in the Water Table Aquifer

Well Number	Maximum Elevation (ft-MSL)	Date	Minimum Elevation (ft-MSL)	Date	Range (ft)	Well Distance from River (ft)
MW-1	141.83	1/2/87	132.29	4/24/86	9.54	180
MW-3	140.11	1/2/87	133.40	11/22/86	6.71	300
MW-5	139.85	12/6/85	134.20	11/22/85	5.65	900
MW-6	139.63	1/2/87	135.74	11/22/85	3.89	1800
MW-8	138.99	1/2/87	136.01	11/22/85	2.98	2000
MW-10	138.41	1/2/87	136.32	11/22/85	2.09	2800
MW-12	143.01	1/2/87	141.11	11/22/85	1.90	6200
MW-15	140.95	1/2/87	133.76	4/24/86	7.19	530
MW-16	140.98	1/2/87	132.70	4/24/86	8.28	180
MW-18	141.17	1/2/87	132.71	4/24/86	8.46	200
MW-19	142.03	1/2/87	138.40	11/2/85	3.63	2900
MW-21	138.58	1/2/87	136.50	12/13/85	2.08	2280
MW-23	138.54	1/2/87	136.95	12/19/85	1.59	2260
MW-24	138.50	1/2/87	137.00	2/7/86	1.50	2270
MW-25	138.57	1/2/87	136.54	12/13/85	2.05	2280
MW-29	138.48	1/2/87	136.57	12/13/85	1.91	2280

Source: REI Field Measurements

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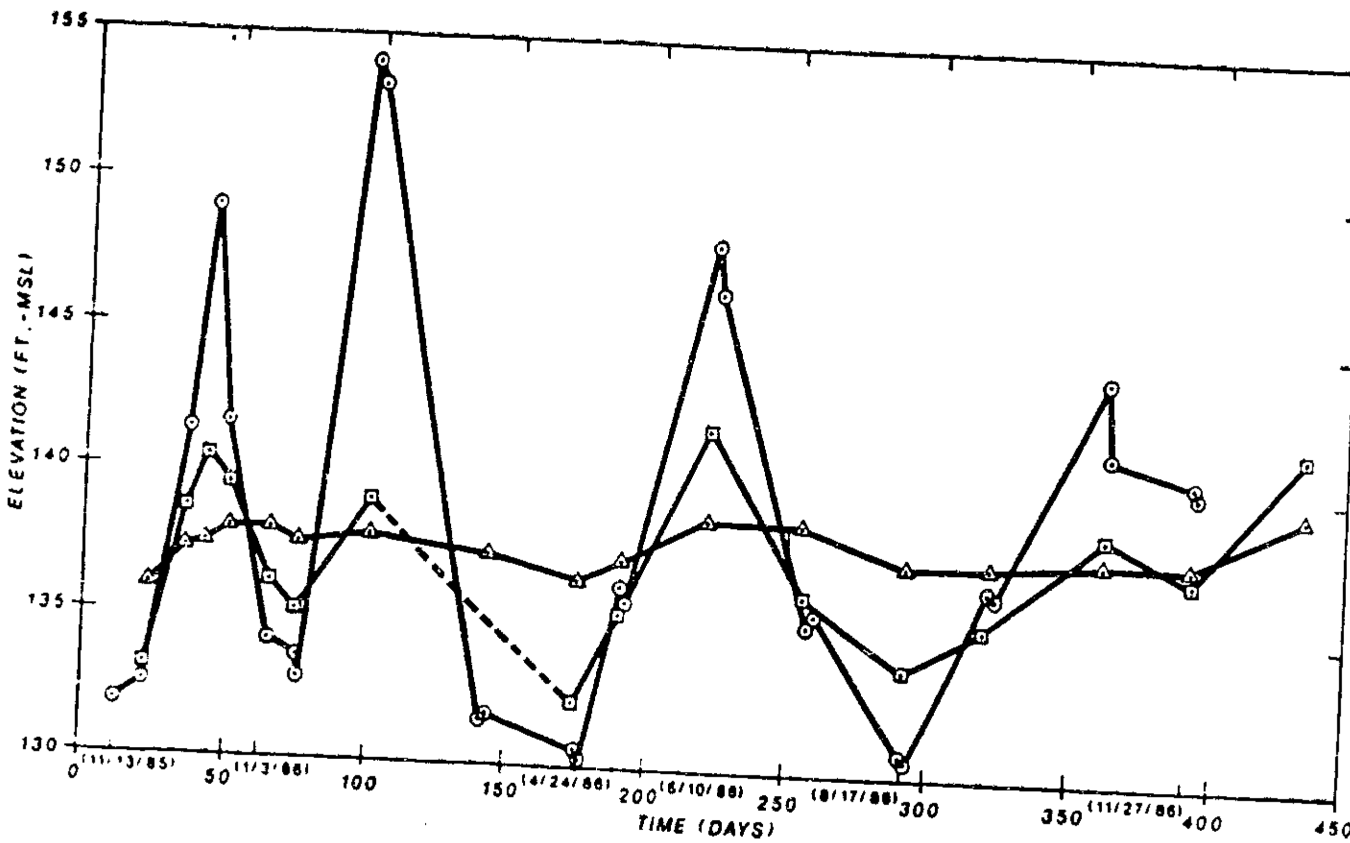

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⊙ BRAZOS RIVER STAGE HEIGHTS

⊡ WATER ELEVATIONS OF MW-1

△ WATER ELEVATIONS OF MW-6

NOTE: ELEVATIONS FOR THE BRAZOS RIVER HAVE BEEN CORRECTED TO RELATIVE SDS SITE ELEVATIONS

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FIGURE 4-12
WATER LEVEL HYDROGRAPH FOR THE BRAZOS RIVER, MW-1 & MW-6
SHERIDAN DISPOSAL SERVICES

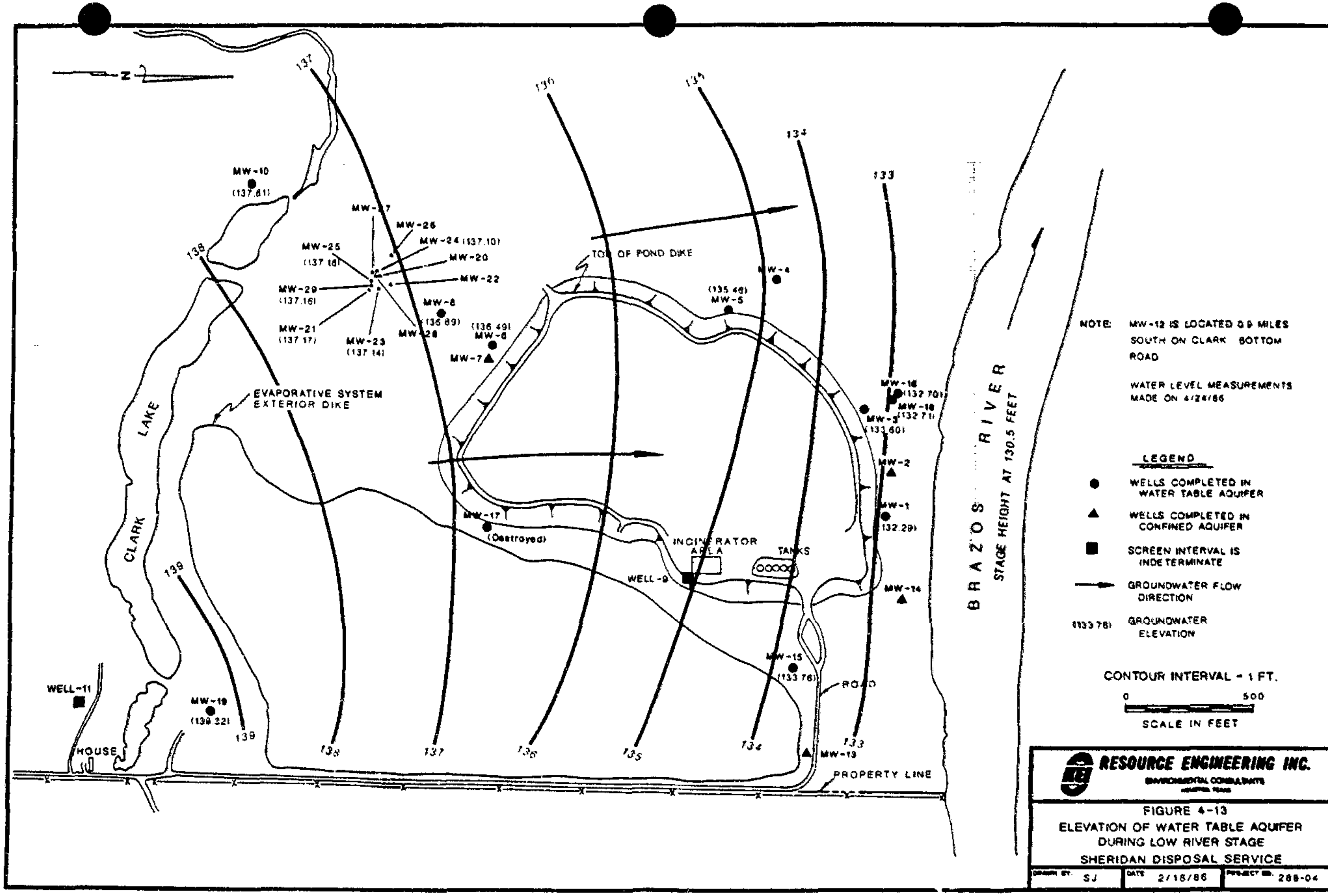
DRAWN BY	DATE	PROJECT NO
RLS	1-16-87	288-04

1700 feet from the river) fluctuated over a range of 3.9 feet. The water level in Well MW-10, about 2800 feet from the river, fluctuated over a range of 2 feet.

The direction of groundwater flow is also dependent on river stage height. During low river stage, the groundwater moves northward and discharges into the river. This is shown in Figure 4-13. Figure 4-13 is based on water-level data obtained on 4/24/86 when the river stage elevation had been low for an extended period of time.

Groundwater flow directions are different during a high river stage period than during a low river stage. The high river stage groundwater flow directions are shown in Figure 4-14. Figure 4-14 is based on water-level data obtained on 2/7/86 when the Brazos River was at one of its highest stages. Groundwater flow near the river is southward, from the river into the water table aquifer. Figure 4-14 shows two main groundwater flow directions. Near the river, it is to the south, while near Clark Lake groundwater flow is to the west-northwest.

This pattern of shifting groundwater flow directions is very consistent; when river stage elevations are low, groundwater flow is northward to the river. As the river stage increase, the groundwater flow direction shifts from north to south; flow is then from the river into the water



MW-10
(137.61)
MW-27
MW-26
MW-24 (137.10)
MW-25
(137.18)
MW-20
MW-22
MW-29
(137.16)
MW-8
(136.89)
MW-21
(137.17)
MW-23
(137.14)
MW-28
(136.49)
MW-6
MW-7
TOP OF POND DIKE
(135.46)
MW-5
MW-4
EVAPORATIVE SYSTEM
EXTERIOR DIKE
LAKE
CLARK
MW-17
(Destroyed)
INCINERATOR
AREA
TANKS
WELL-9
MW-16
(132.70)
MW-18
(132.71)
MW-3
(133.60)
MW-2
MW-1
(132.29)
MW-14
MW-15
(133.76)
ROAD
MW-13
PROPERTY LINE
WELL-11
HOUSE
MW-19
(139.22)
139
138
137
136
135
134
133
BRAZOS RIVER
STAGE HEIGHT AT 130.5 FEET
NOTE: MW-12 IS LOCATED 0.9 MILES SOUTH ON CLARK BOTTOM ROAD
WATER LEVEL MEASUREMENTS MADE ON 4/24/86
LEGEND
WELLS COMPLETED IN WATER TABLE AQUIFER
WELLS COMPLETED IN CONFINED AQUIFER
SCREEN INTERVAL IS INDETERMINATE
GROUNDWATER FLOW DIRECTION
(133.76) GROUNDWATER ELEVATION
CONTOUR INTERVAL = 1 FT.
0 500
SCALE IN FEET
RESOURCE ENGINEERING INC.
ENVIRONMENTAL CONSULTANTS
FIGURE 4-13
ELEVATION OF WATER TABLE AQUIFER
DURING LOW RIVER STAGE
SHERIDAN DISPOSAL SERVICE
DRAWN BY: SJ
DATE 2/18/86
PROJECT NO. 288-04

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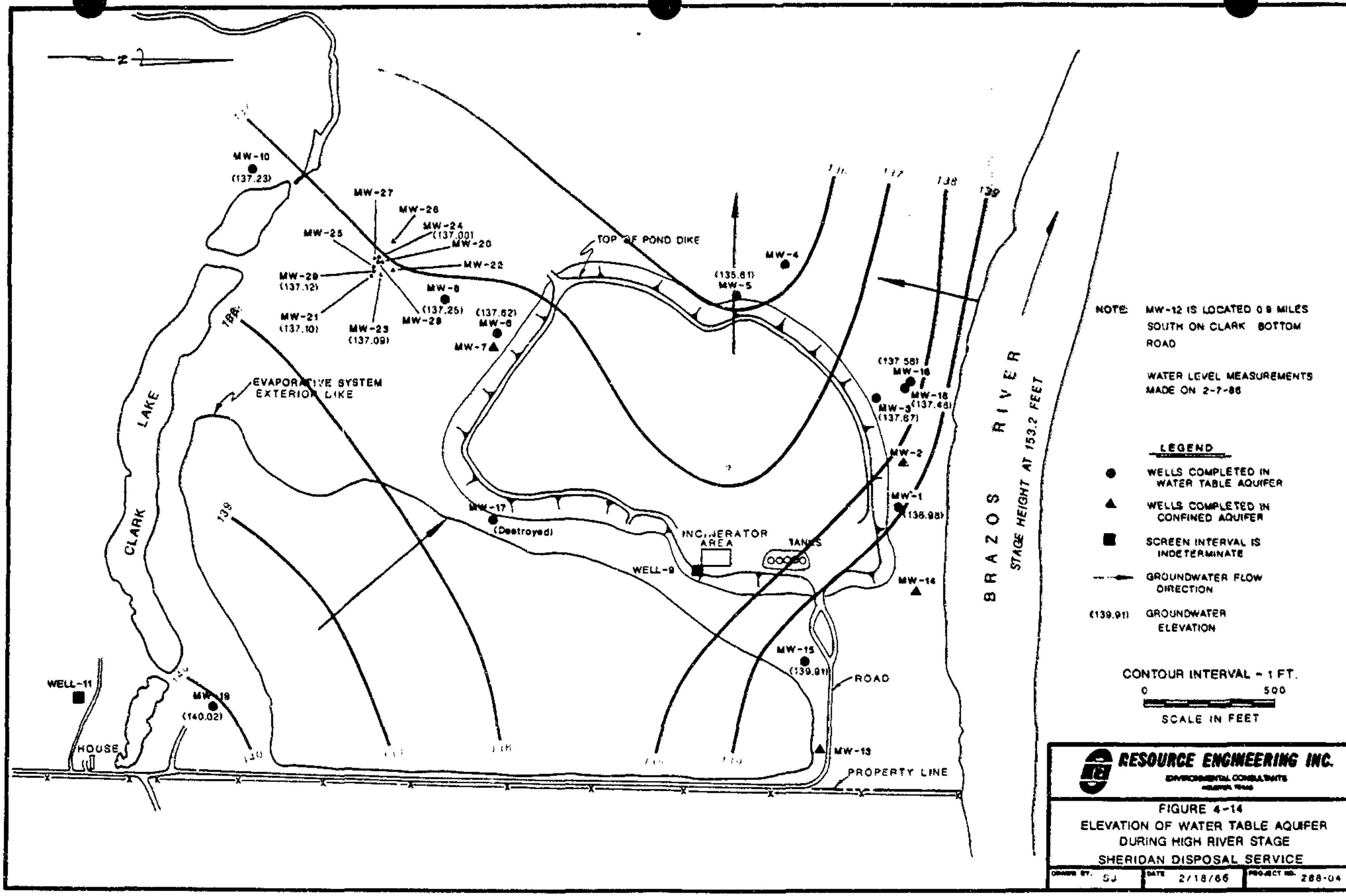

FIGURE 4-14
ELEVATION OF WATER TABLE AQUIFER
DURING HIGH RIVER STAGE
SHERIDAN DISPOSAL SERVICE

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table aquifer. Figure 4-11 shows that numerous high river stage peaks occurred on the Brazos River to document this pattern.

The frequency and duration of groundwater movement from the river into the water table aquifer cannot be determined from the data available.

Groundwater velocities vary during the year based on the groundwater gradient. The steeper the gradient, the faster the rate of groundwater flow. Table 4-10 shows groundwater velocities vary from 57 to 157 feet/year and are dependent on river stage. The formula used to calculate the velocities was: 0035920

$$V = \frac{\frac{K(h_1-h_2)}{L}}{n}$$

Where

V = velocity
K = hydraulic conductivity
h = height of water observed in well
L = distance between wells
n = porosity

Table 4-10

Water Table Aquifer (Strata A and B) Groundwater Velocities

Date	Hydraulic Gradient (ft/ft)	Velocity (ft/yr)	Groundwater flow direction	River Stage
2/7/86	0.0046	157	south	high
2/7/86	0.0021	71	northwest	high
4/24/86	0.0017	57	north-northwest	low

Note: Hydraulic gradient measured at groundwater direction arrows in Figures 4-13 and 4-14. Effective porosity was 24 percent based on sieve analysis shown in Appendix 4A.

The amount of groundwater flowing from the alluvium at the site into the Brazos River can be calculated using Darcy's flow equation. The contributing area was measured from the eastern edge of the pond to the western property boundary (1400 feet). Based on this measurement, a saturated thickness of 20.7 feet, hydraulic gradient of 0.0021 ft/ft on 11/22/85 and a hydraulic conductivity of 8160 ft/yr, the flow into the river is 7.1 gpm. The flow in the river at the Hempstead station on 11/22/85 was 1.2 million gpm. Groundwater flow from the SDS site makes a very insignificant contribution (0.00032%) to total Brazos River flow.

4.5.2 First Confined Aquifer - Underlying the water table aquifer, and separated from it by a clay aquiclude, is the first confined aquifer (Stratum D). An aquifer is called confined if the water will rise above the bottom of the confining bed to an elevation at which it is in balance with atmospheric pressure and which reflects the pressure in the aquifer at the point of penetration. The first confined aquifer at the site is a 10 to 12-foot thick sand layer that is approximately 85 feet below grade. The confining layer is a 25 to 30-foot thick clay layer (Stratum C) immediately above the sand. Stratum C separates the first confined aquifer from the water table aquifer (Strata A and B).

Several wells have been installed in the first confined aquifer. The first well, Well-9, was used as a production well for the facility to supply washdown water. Construction details for Well-9 are not available and this well may not be screened in the first confined or water table aquifer. A second well, MW-2, was completed in the first confined aquifer in 1972 to comply with the site's waste disposal permit and subsequently has been converted into a stock watering well. REI has installed 8 additional wells in the first confined aquifer since 1984. 0035940

4.5.2.1 <u>Hydraulic Characteristics</u> - One pumping well (MW-20) and 4 piezometers (MW-22,26,27,28) were installed to fully penetrate the aquifer. These wells were used to determine the hydraulic characteristics of the confined aquifer. The well locations were chosen according to the EPA approved "Hydrological Investigation Plan." Protective surface casings were installed in the pump test well and the piezometers to isolate the confined aquifer from the water table aquifer. The construction details of these monitor wells are described in Appendix 4B. Development procedures are discussed in Appendix 4C.

A pump test was conducted on 2/11/86 with a pumping rate of 10.3 gpm. Several methods were used to analyze the data including: Theis curve matching, Hantush-Jacob leaky aquifer solution, time-drawdown, recovery, and distance-drawdown. These five analytical methods were used to cross-check the validity of the mathmatical solution to determine if aquifer characteristics were consistent. All the methods produced similar results, and are summarized in Table 4-11. Graphs and calculations are presented in Appendix 4-F.

Table 4-11 lists the average permeability, transmissivity, and storage coefficient as 5.8×10^{-3} cm/sec, 1.4×10^{3} gpd/ft and 7.6×10^{-4} (unitless), respectively. The permeability was calculated using an average saturated thickness of 11 feet based on drilling logs. The permeability value is within the range of published permeabilities for a fine to medium grained sand. The values indicate that there is potential for good water movement through this aquifer. The aquifer would easily sustain a domestic water well, but may not sustain a low producing irrigation well. It could not sustain a municipal production well.

4.5.2.2 <u>Groundwater Flow</u> - The first confined aquifer may be hydraulically connected to the Brazos River at some point. Eight monitoring wells have been

Table 4-11

Summary of Hydraulic Characteristics of the First Confined Aquifer (Stratum D)

Well Number	Analysis Method	Hydraulic conductivity (cm/sec)	Trans-missivity (gpd/ft)	Storage Coefficient
	Theis curve	8.3×10^{-3}	1.9×10^{3}	2.2×10^{-4}
	H-J Leaky aquifer	7.2×10^{-3}	1.7×10^{3}	1.6×10^{-4}
MW-22	Time-drawdown	1.2×10^{-3}	3.0×10^{3}	1.2×10^{-4}
	Recovery	8.3×10^{-3}	1.9×10^{3}	*
	Theis curve	1.2×10^{-2}	2.8×10^{3}	1.7×10^{-4}
	H-J Leaky aquifer	5.2×10^{-3}	1.2×10^{3}	1.5×10^{-4}
MW-26	Time-drawdown	1.4×10^{-2}	3.4×10^{3}	1.3×10^{-4}
	Recovery		not monitored	
	Theis curve	3.1×10^{-3}	7.3×10^{2}	2.4×10^{-4}
	H-J Leaky aquifer	1.6×10^{-3}	3.6×10^{2}	2.3×10^{-4}
MW-27	Time-drawdown	2.8×10^{-3}	6.5×10^{2}	2.0×10^{-4}
	Recovery	2.8×10^{-3}	6.5×10^{2}	*
	Theis curve	1.4×10^{-3}	3.3×10^{2}	1.4×10^{-3}
	H-J Leaky aquifer	1.8×10^{-3}	4.2×10^{2}	1.4×10^{-3}
MW-28	Time-drawdown	1.9×10^{-3}	4.6×10^{2}	1.1×10^{-3}
	Recovery		not monitored	
All four piezometers	distance drawdown	4.7×10^{-3}	1.1×10^{3}	4.4×10^{-3}
Average		5.8×10^{-3}	1.4×10^{3}	7.6×10^{-4}

*Storage coefficient not available with this method.

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installed in the confined aquifer; see Figure 4-10. Figure 4-15 shows the relationship between river stage elevations and the water-level elevation in MW-13. Based on observation of saturated thickness, well MW-13 is representative of all the wells in the confined aquifer. Since it is located near the river, it should show the maximum, if any, effects of the river state changes. Figure 4-15 shows water-level fluctuations in the first confined aquifer follows the same pattern as river changes. However, the fluctuations are subdued and there is a lag time.

The range of water-level fluctuations in 8 monitoring wells are summarized in Table 4-12. All 8 monitoring wells had similar ranges. Wells MW-7, MW-13 and MW-14 had the largest range. This is possibly due to two reasons. These 3 wells are closer to the river which may have some effect and they were monitored for a longer period of time. A complete list of water level measurements is contained in Attachment 4E.

The potentiometric surface of the confined aquifer is almost level. As a result, any changes in the piezometric potential (water-level) can change the direction of flow. Water level elevations were plotted using all the available data. Groundwater flow at the site is generally westerly. However, the flow direction varied from

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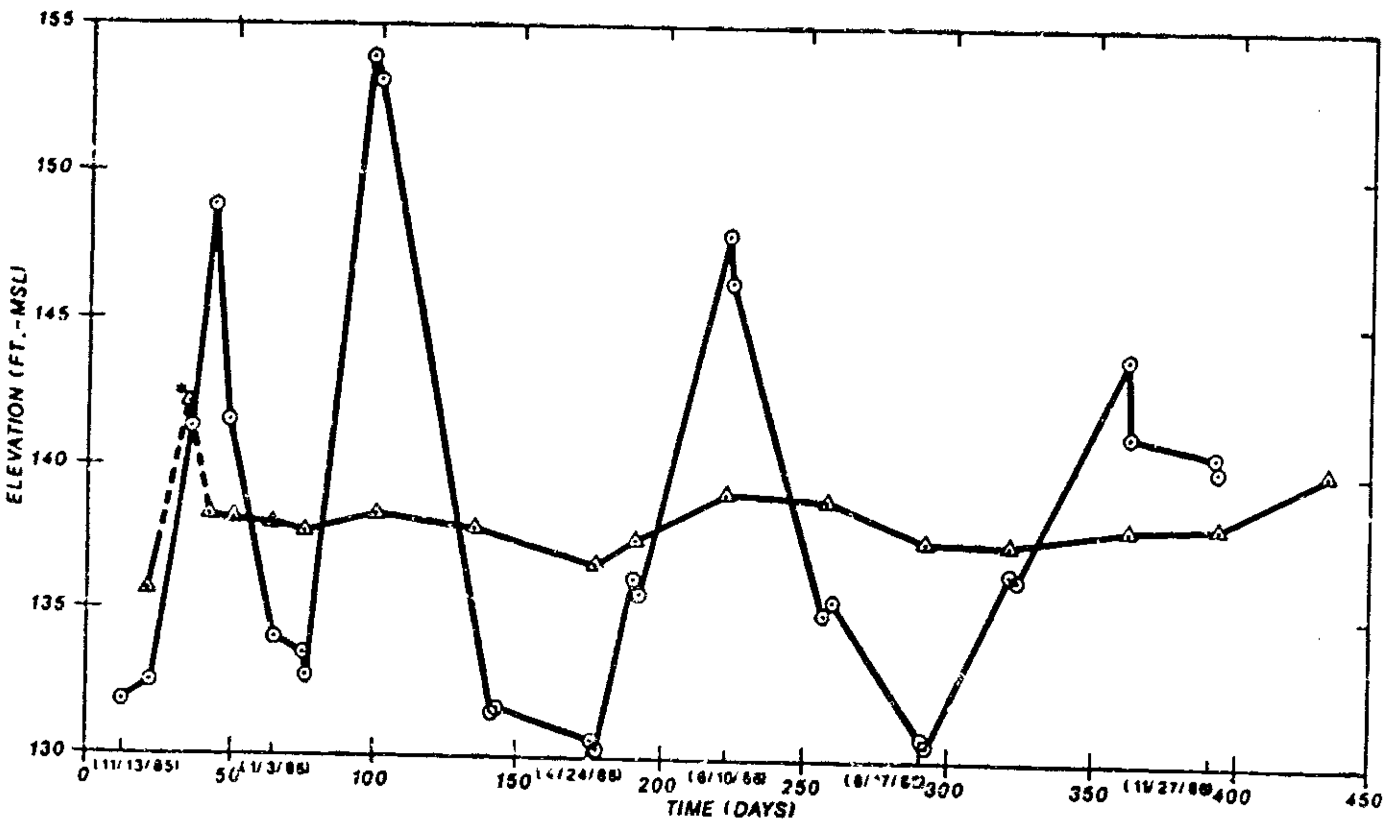

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⊙ BRAZOS RIVER STAGE HEIGHTS

△ PIEZOMETRIC POTENTIAL OF MW-13

* APPARENT MEASUREMENT ERROR

NOTE: ELEVATIONS FOR THE BRAZOS RIVER HAVE BEEN CORRECTED TO RELATIVE SDS SITE ELEVATIONS

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FIGURE 4-15
WATER LEVEL HYDROGRAPH FOR THE BRAZOS RIVER AND MW-13
SHERIDAN DISPOSAL SERVICES

DRAWN BY	DATE	PROJECT NO
RLS	1-16-87	288-04

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Table 4-12

Range of Water-Level Elevation in First Confined Aquifer

Well Number	Maximum Elevation (ft-MSL)	Date	Minimum Elevation (ft-MSL)	Date	Range (ft)	Well Distance from River (ft)
MW-7	139.66	1/2/87	135.71	11/22/85	3.95	1970
MW-13	140.32	1/2/87	136.70	4/24/85	3.62	530
MW-14	140.29	1/2/87	135.48	11/22/85	4.81	100
MW-20	139.59	1/2/87	137.10	4/24/86	2.49	2270
MW-22	139.56	1/2/87	137.07	4/24/86	2.49	2220
MW-26	139.55	1/2/87	137.07	4/24/86	2.48	2270
MW-27	139.56	1/2/87	137.19	4/24/86	2.37	2280
MW-28	139.44	1/2/87	137.04	4/24/86	2.40	2270

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Table 4-13

Groundwater Flow Direction in the First Confined Aquifer

Date	Flow Direction*	Brazos River Stage Height
2/7/86	west	high
4/24/86	east	low
5/9/86	northwest	low
6/11/86	northwest	high
7/15/86	west-southwest	low-medium
8/18/86	northwest	low
9/18/86	northwest	low-medium
10/27/86	west	high
11/28/86	southwest	high
1/2/87	south-southwest	high

* Flow direction based on Wells MW-7, MW-13, and MW-14.

east to northwest to southwest. This is shown in Table 4-13. The GWMMRI will further assess the piezometric potential gradient of the confined aquifer.

Table 4-13 lists the groundwater flow directions on various dates and the relative stages of the Brazos River for those dates. The groundwater flow direction is westerly a majority of the time. Table 4-13 suggests there may be a correlation between flow direction and stage. During prolonged low river stage (2 to 3 months), the flow direction is to the northwest. During prolonged high river stage, the flow direction shifts to a southerly direction. The flow direction can oscillate between these two directions during quickly changing river stage events.

Figure 4-16 shows the piezometric potential of the first confined aquifer on 2/7/86. A triangulation method (three-point problem) was used between wells MW-7, MW-13, and MW-14 to determine the direction of flow. As shown in the figure, the potential or inferred flow is to the west. However, the wells in the cluster (MW-20, 22, 26, 27 and 28) show a different flow pattern.

The groundwater flow varies and conflicts with the flow direction shown in Figure 4-16. This is not an anomaly. All the data from the wells in this cluster showed conflicting flow directions. There are several possible explanations for these inconsistencies. The well cluster is over 2000 feet from the river. It may take awhile for the

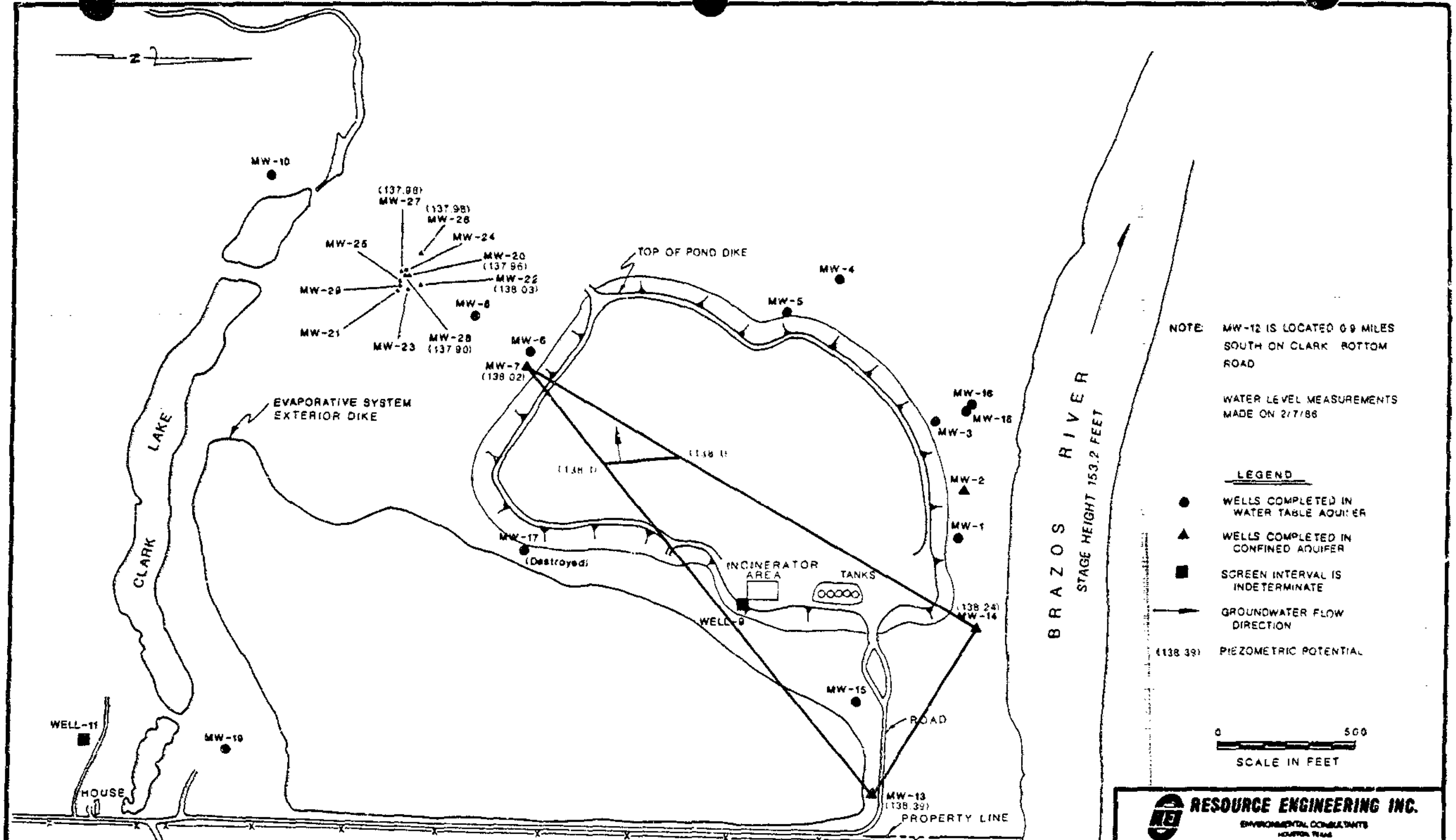

FIGURE 4-16
POTENTIOMETRIC SURFACE OF THE CONFINED AQUIFER DURING HIGH RIVER STAGE
SHERIDAN DISPOSAL SERVICE

DRAWN BY SJ	DATE 2/18/86	PROJECT NO. 288-04

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effects of changes in river stage to reach the wells. Wells in the cluster indicate one flow direction. The wells near the river may indicate a different flow direction. This would be synonymous to a "wave" moving through the aquifer.

Also, well MW-27 is screened in a stratum that is lithologically different than the other wells. This would possibly create a different piezometric potential in well MW-27. There are also slight lithologic variations in the other wells which may create slight differences in the piezometric potential. As mentioned, because the potentiometric surface is essentially level, any change in the piezometric potential at a point (well) can cause a change in flow direction. During the monitoring period, it was observed that very large and deep cracks appeared in soil. Two of these cracks went through wells MW-22 and MW-28 and heaved the concrete pad and protective casing up by 2 to 3 inches. Water level elevations were measured from the top of the protective casing. As a result, the piezometric potential calculated from wells MW-22 and MW-28 will be off by several tenths of a foot. The accuracy of the water level measurements is approximately 0.05 feet, so the smallest measuring error could change the direction of flow. Therefore, caution must be exercised in reaching any conclusions about groundwater flow direction in the first confined aquifer based on these data.

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Groundwater velocities vary during the year based on the gradient of the piezometric surface (e.g., the steeper the gradient, the faster the flow). Table 4-14 gives a range of groundwater velocities and general direction at different times. Table 4-14 shows that groundwater velocities are very slow and the flow direction is variable. Water level measurements are found in Appendix 4E.

Table 4-14

Groundwater Velocities and Direction of the Confined Aquifer (Stratum D)

Date	Hydraulic Gradient (ft/ft)	Velocity (ft/yr)	Direction	River Stage
5/9/86	0.00030*	6.7	northwest	low
6/11/86	0.00027*	6.0	northwest	high
11/28/86	0.00014**	3.1	southwest	high

* Hydraulic gradient measured between wells MW-13 and MW-14
** Hydrualic gradient measured between wells MW-13 and MW-7
Hydraulic conductity = 5.8 x 10^{-3} cm/sec for calculations

Note: Velocities were calculated using an effective porosity of 27 percent, based on sieve analysis shown in Appendix 4A.

4.5.2.3 Hydraulic Potential - A hydraulic potential exists for groundwater to flow downward from the water table aquifer to the first confined aquifer, if the water elevation of the water table aquifer is greater than the piezometer potential in the confined aquifer. Groundwater will flow upward from the first confined towards the water table aquifer, if the piezometric potential of the first confined

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aquifer is greater than the water level elevation in the water table aquifer.

Three wells from the water table aquifer were paired with three wells from the first confined aquifer to determine the direction of the hydraulic potential (vertical, hydraulic gradient). The paired wells are in close proximity to each other to determine the hydraulic potential at that point. The paired wells are: MW-13/MW-15, MW-6/MW-7, and MW-20/MW-29.

Additional wells are proposed to be installed in the first confined aquifer as part of the Groundwater Migration Management RI. These monitoring wells will be used to better define the direction of flow in the confined aquifer.

Tables 4-15, 4-16, and 4-17 show the water levels elevations for each pair and the direction of the hydraulic potential. Table 4-15, pair MW-13/MW-15, shows that the direction of the hydraulic potential frequently switches back and forth. When these data are compared to river stage elevations, it is apparent that the hydraulic potential is downward during high river stages and upward during low river stages.

Pair MW-6/MW-7 is farther from the river and high river stages have less of an effect on the direction of the hydraulic potential. Table 4-16 shows that the hydraulic potential is upward most of the time.

Table 4-15

Hydraulic Potential at MW-13 and MW-15

Date	Elevation MW-13* (ft-MSL)	Elevation MW-15** (ft-MSL)	Hydraulic Potential Direction
11/22/85	135.62	135.32	up
12/6/85	142.16***	138.35	-
12/13/85	138.19	139.73	down
12/19/85	138.10	139.28	down
1/3/86	138.05	136.56	up
1/14/86	137.82	135.85	up
2/7/86	138.39	139.91	down
3/21/86	137.90	134.91	up
4/24/86	136.70	133.76	up
5/9/86	137.58	136.58	up
6/11/86	139.59	140.51	down
7/15/86	139.01	137.24	up
8/18/86	137.78	134.59	up
9/18/86	137.70	136.75	up
10/27/86	138.31	139.14	down
11/28/86	138.46	138.51	down
1/2/87	140.32	140.95	down

* Monitor well installed in confined aquifer

** Monitoring well installed in water table aquifer

***Elevation incorrect due to apparent measuring error

Table 4-16

Hydraulic Potential at MW-6 and MW-7

Date	Elevation MW-13* (ft-MSL)	Elevation MW-15** (ft-MSL)	Hydraulic Potential Direction
11/22/85	135.74	135.71	down
12/6/85	137.15	136.98	down
12/13/85	137.34	137.68	up
12/19/85	137.88	137.69	down
1/3/86	137.8	137.68	down
1/14/86	137.48	137.47	down
2/7/86	137.62	138.02	up
3/21/86	137.33	137.54	up
4/24/86	136.49	136.88	up
5/9/86	137.28	137.43	up
6/11/86	138.57	138.78	up
7/15/86	138.55	138.68	up
8/18/86	137.40	137.63	up
9/18/86	137.54	137.65	up
10/27/86	138.26	138.16	down
11/28/86	138.17	138.19	up
1/2/87	139.63	139.66	up

* Monitoring well installed in water table aquifer

** Monitoring well installed in confined aquifer

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Table 4-17

Hydraulic Potential at MW-20 and MW-29

Date	Elevation MW-20* (ft-MSL)	Elevation MW-29** (ft-MSL)	Hydraulic Potential Direction
12/13/85	137.51	136.57	up
12/19/85	137.67	137.00	up
1/3/86	137.70	137.43	up
1/14/86	137.54	137.28	up
2/7/86	137.96	137.12	up
3/21/86	137.15	139.25***	-
4/24/86	137.10	137.16	down
5/9/86	137.53	137.24	up
6/11/86	138.70	137.78	up
7/15/86	138.63	138.25	up
8/18/86	137.84	137.78	up
9/18/86	139.67***	137.70	-
10/27/86	138.33	137.82	up
11/28/86	138.37	137.97	up
1/2/87	139.59	138.48	up

* Monitoring well installed in confined aquifer

** Monitoring well installed in water table aquifer

***Elevation incorrect due to apparent measuring error

003608

Pair MW-20/MW-29 is the farther pair from the river; the river has even a lesser influence at this pair. Table 4-17 shows that the hydraulic potential was downward only on 4/24/86. The rest of the time the hydraulic potential was upward.

The duration that any particular hydraulic potential direction lasts, or when it changes, cannot be conclusively determined from available data. The GWMM R.I. will address this issue further.

4.5.3 Hydraulic Characteristics of Site Aquicludes

There are three strata on site that restrict vertical groundwater flow: A, C and E. Laboratory and field permeabilities were measured for these three strata.

Three in situ field permeabilities were measured in the silty clay of Stratum A. Details of construction, location and calculations are shown in Appendix 4-G. Field results were compared to laboratory permeability results. Laboratory permeability was calculated using the Falling Head Permeability Test with superimposed air pressure on undisturbed soil samples following the Army Corps of Engineers Manual EM 1110-2-1906. Table 4-18 compares the laboratory results and the field results.

Table 4-18

In Situ and Laboratory Permeabilities of Stratum A

Laboratory Results			Field Result		
Borehole Number	Depth (ft)	Permeability (cm/sec)	Slug Test Number	Depth (ft)	Permeability (cm/sec)
20	6	8.1×10^{-9}	4	23	5.4×10^{-9}
21	10	8.6×10^{-9}	5	23	7.9×10^{-9}
22	6	2.4×10^{-9}	6	23	1.7×10^{-8}

Table 4-18 compares the in situ results to laboratory results from boreholes that are in the same stratigraphic unit. These were designed to measure the permeability of the silty clay under the evaporation system as detailed in the HIP.

All results show that the silty clay has a low permeability, 10^{-8} to 10^{-9} cm/sec. This low permeability restricts the infiltration of rainwater and the vertical movement of groundwater.

Stratum C is a dense clay layer separating the two sand layers, Strata B and D. Laboratory hydraulic conductivities were measured on 8 samples from this stratum and are listed in Table 4-19. The hydraulic conductivities ranged from 7.6×10^{-7} to 8.4×10^{-10} cm/sec and the median was 4.4×10^{-8} cm/sec.

003610

In some cases, the hydraulic conductivity of the upper confining clay can be calculated from pumping test data. Pumping test data were analyzed using the Modified Hantush theory, Hantush-Jacob method, and the Bureau of Reclamation analysis. Results of these analyses are shown in Table 4-20. Table 4-20 shows the hydraulic conductivity of Stratum C ranged from 2.3 x 10^{-3} to 1.4 x 10^{-5} cm/sec with a median value of 2.2 x 10^{-4} cm/sec.

The Hantush-Jacob and Bureau of Reclamation methods calculate a hydraulic conductivity for the upper confining clay (Stratum C) by pumping the confined aquifer (Stratum D), and assuming that all recharge is by leakage through Stratum C. These methods do not account for recharge into Stratum D from the units underlying Stratum D. Nor do they account for recharge to Stratum D from storage within Stratum C. Thus, the apparent hydraulic conductivities of Stratum C calculated by these methods may be artificially high.

The Modified Hantush method incorporates the effects of recharge to Stratum D from storage within the confining Stratum C, as well as leakage through Stratum C, and thus is a more applicable theory. The hydraulic conductivities of Stratum C calculated by the Modified Hantush method under the assumptions that all recharge to Stratum D is derived from leakage through and storage within Stratum C are given in Table 4-20. Leakage through and storage within Stratum E were not considered in these analyses. The values derived from the

Table 4-19

Laboratory Permeabilities for

Stratum C

Well Number	Sample Depth Interval (ft)	Permeability (cm/sec)
	61-62	6.6×10^{-8}
MW-7	66-68	8.8×10^{-8}
	74-76	5.8×10^{-8}
	78-80	2.9×10^{-8}
MW-13	60-62	8.1×10^{-10}
MW-14	63-65	8.4×10^{-10}
MW-16	59-61	1.0×10^{-8}
MW-17	57-59	7.6×10^{-7}

003612

Table 4-20

Hydraulic Conductivity of the Upper Confining Clay (Stratum C)

Well Number	Analysis Method	Hydraulic Conductivity (cm/sec)
MW-22	Bureau of Reclamation	1.4×10^{-5}
	Hantush - Jacob	1.2×10^{-4}
	Modified Hantush	4.0×10^{-4}
MW-26	Bureau of Reclamation	4.0×10^{-5}
	Hantush - Jacob	1.2×10^{-4}
	Modified Hantush	2.0×10^{-4}
MW-27	Bureau of Reclamation	1.4×10^{-4}
	Hantush - Jacob	2.4×10^{-4}
	Modified Hantush	3.6×10^{-4}
MW-28	Bureau of Reclamation	6.6×10^{-4}
	Hantush - Jacob	1.4×10^{-3}
	Modified Hantush	2.3×10^{-3}

003613

Modified Hantush theory are consistent with those derived from the other two theories, but may still be artificially high because of possibility of recharge to Stratum D from below during the pumping test.

The Modified Hantush theory can also be applied to situations in which recharge to the pumped unit (Stratum D) is derived from leakage through and storage within the underlying confining unit (Stratum E) as well as through the overlying confining unit (Stratum C). However, in such a situation, the method cannot be used to directly calculate the hydraulic conductivity of either confining layer. Rather, the method allows for calculating the sum of the leakances (ratio of hydraulic conductivity to thickness of a confining unit) of the two confining strata. Individual values of the Hydraulic conductivity of the two confining strata can only be estimated by making assumptions regarding their probable relative values. If it is assumed that the thicknesses and hydraulic conductivities of Strata C and E are of the same order of magnitude (assumptions which are generally consistent with other available data on these units, although data from Stratum E are very limited), then the resulting estimated value of the hydraulic conductivity of Stratum C would be approximately the same as the values reported in Table 4-20.

The Bureau of Reclamation, Hantush-Jacob, and Modified Hantush methods of pumping test analysis all rely on curve matching techniques for the estimation of aquifer

003614

parameters. In some instances, it is difficult to match observed field data to the theoretical type curves, and the resulting parameter estimates must be used with caution. However, when an acceptable match of the field data to the type curve can be made, this technique can be very useful in estimating aquifer parameters. In general, pumping test data are preferable to other methods for estimating aquifer properties because they are applicable at the scale of groundwater flow through the aquifer, rather than at a smaller scale as in the case of single-well tests or laboratory tests. However, pumping test data must be carefully evaluated on a site specific basis.

The hydraulic conductivity calculated for Stratum C using the leaky aquifer analysis appears to be somewhat high. Numerous borings have been advanced and logged through Stratum C. It was observed that this clay is very tight, dense, and plastic. A hydraulic conductivity of 7.8×10^{-4} cm/sec corresponds to silt or fine sand (Ground Water Manual, Bureau of Reclamation, 1977). This was not the nature of the material observed in the field.

Samples were collected from Stratum C and analyzed in the laboratory. Laboratory permeabilities ranged from 7.6×10^{-7} to 8.4×10^{-10} cm/sec. These values are much lower than the values calculated from the pumping tests, and are generally consistent with values expected for massive clays (Ground Water Manual, Bureau of Reclamation, 1977). It should be noted,

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however, that laboratory measurements test the hydraulic conductivity of only a point sample from within the aquifer, and cannot account for field-scale phenomena, such as gross aquifer heterogeneity, which may affect groundwater flow through the aquifer and its confining beds. These phenomena may explain at least in part, why pumping tests frequently result in calculated hydraulic conductivities that are several orders of magnitude greater then those calculated using laboratory data.

In general, it is likely that the laboratory and aquifer test estimates of the hydraulic conductivity of Stratum C provide, respectively, lower and upper bounds of the actual hydraulic conductivity. The effective hydraulic conductivity of the confining unit is likely to be higher than that calculated from the laboratory tests because of field-scale phenomena not accounted for in those tests, and it is likely to be lower than that calculated from the leaky aquifer theory because of the difficulties in distinguishing the effects of leakage through both the overlying and underlying confining units.

The hydraulic conductivity of Stratum C was used to estimate the time required for water to move through Stratum C. A conservative, or worst case, scenario for travel time would utilize a hydraulic conductivity (K) of 2.2×10^{-4} cm/sec (median value from pump test calculations), a downward head difference of 1.5 feet (one of the largest downward gradients

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observed), and an effective porosity of 0.25. Under these conditions, the travel time through Stratum C is 329 days (.9 years). However, a scenario which is probably more representative of actual field conditions utilizes a K = 7.4 x 10^{-6} cm/sec (median K value for Stratum C), a downward head difference of 0.5 feet (the average observed difference), and an effective porosity of 0.25. Under these conditions, the travel time is 81 years.

The median Hydraulic conductivity used in the representative travel time was calculated using the Hydraulic conductivities from the results from the pumping test data and the laboratory permeabilities. The analytical values from well MW-28 were not used because the well is in immediate proximity (6.4 feet) of the pumping well, MW-20. The large (40 feet) and rapid drawdown in the pumping well would have created head loss not only in the pumping well, but also in MW-28. For this reason, the analytical results from MW-28 were not used in calculating the median value.

Under worst case conditions, it would take approximately .9 years for water to travel across Stratum C. However, as discussed in Section 4.5.2.3 and shown in Table 4-17, the water level elevations from monitor wells in the pumping test area indicate that the predominant direction of Hydraulic potential is upward, into the water table aquifer.

003617

Only during high river stage is the potential downward. The annual net flow direction is upward into the water table aquifer.

Stratum E is a very dense, blocky clay that is the lowest unit of interest on site. One sample was collected from MW-13 at the 113 to 114 foot interval and was analyzed in the laboratory. The laboratory permeability was 4.5×10^{-10} cm/sec.

003618

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5.0 SURFACE WATER INVESTIGATIONS

5.1 Surface Water Bodies

5.1.1 Brazos River - The Brazos River is the dominant surface water feature in the area. The headwaters of the Brazos River are in eastern New Mexico and the panhandle of Texas. It meanders southeast and discharges into the Gulf of Mexico near Freeport, Texas. The Brazos River is a mature river with many meander scars, as evidenced by the oxbow lakes along the river.

The U. S. Geological Survey (USGS) operates the Hempstead, Texas flow recording station (#08111500) on the Brazos River approximately 14 miles downstream of the Sheridan Disposal Service site. The drainage area is 43,880 square miles at this station, and has an average discharge of 6,627 cubic feet per second (cfs). The maximum discharge on record is 143,000 cfs on May 2, 1957; the minimum discharge was 137 cfs on November 6, 1952. This station has operated since 1938.

Figure 5-1 is a summary of maximum, mean, and average discharge rates for the Brazos River at this station for the water year 1982, October, 1981 through September, 1982. This water year was chosen as typical in terms of time and duration of peak flow based on a comparison to previous water years. The figure shows significant variations in volumetric flow rates which are typical of the Brazos River. Figure 5-2 is a hydrograph for water year 1982. Peak discharges during this water year occur in the fall and late spring/early summer.

0036271

REFERENCES

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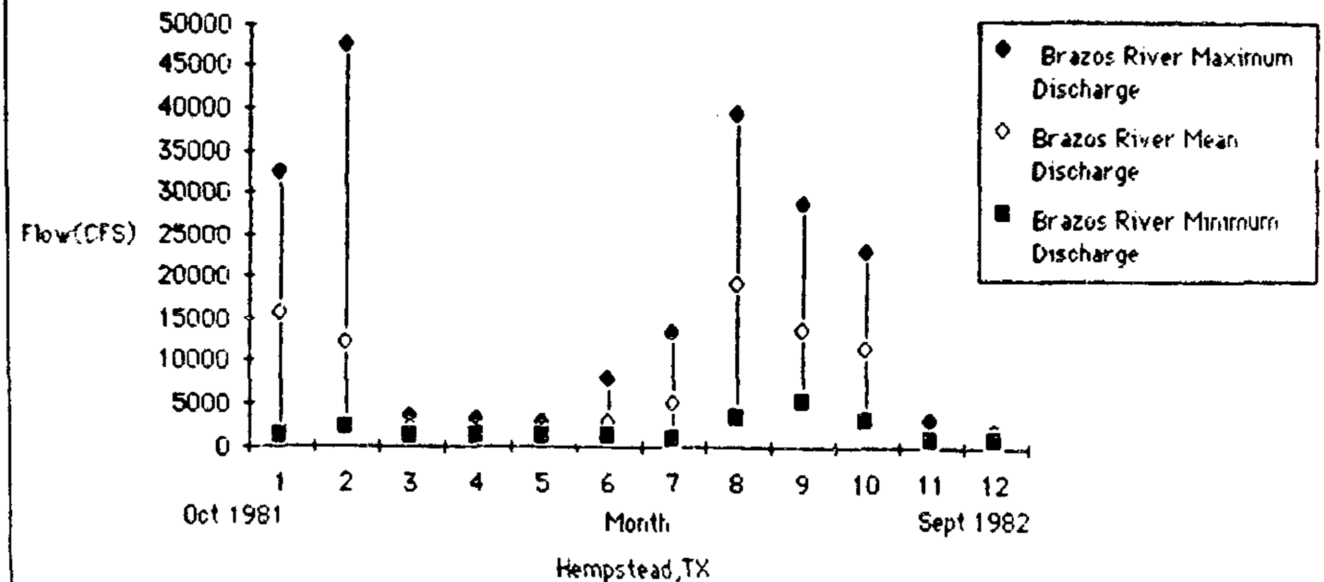
Figure 5-1

Brazos River Discharge



source:U.S.G.S Water Resources Data -Texas,V2

Additional analysis, if necessary, will be included in the Groundwater Migration Management Remedial Investigation report.

The Texas Water Commission (TWC) has classified this segment of the Brazos River (number 1202) as effluent limited based on upstream discharges and as being fishable and swimmable. Effluent limited stream segments require permits for pollutant discharges. Title 31 of the State of Texas Natural Resources and Conservation Regulations limits the maximum pollutant loading for this water segment to:

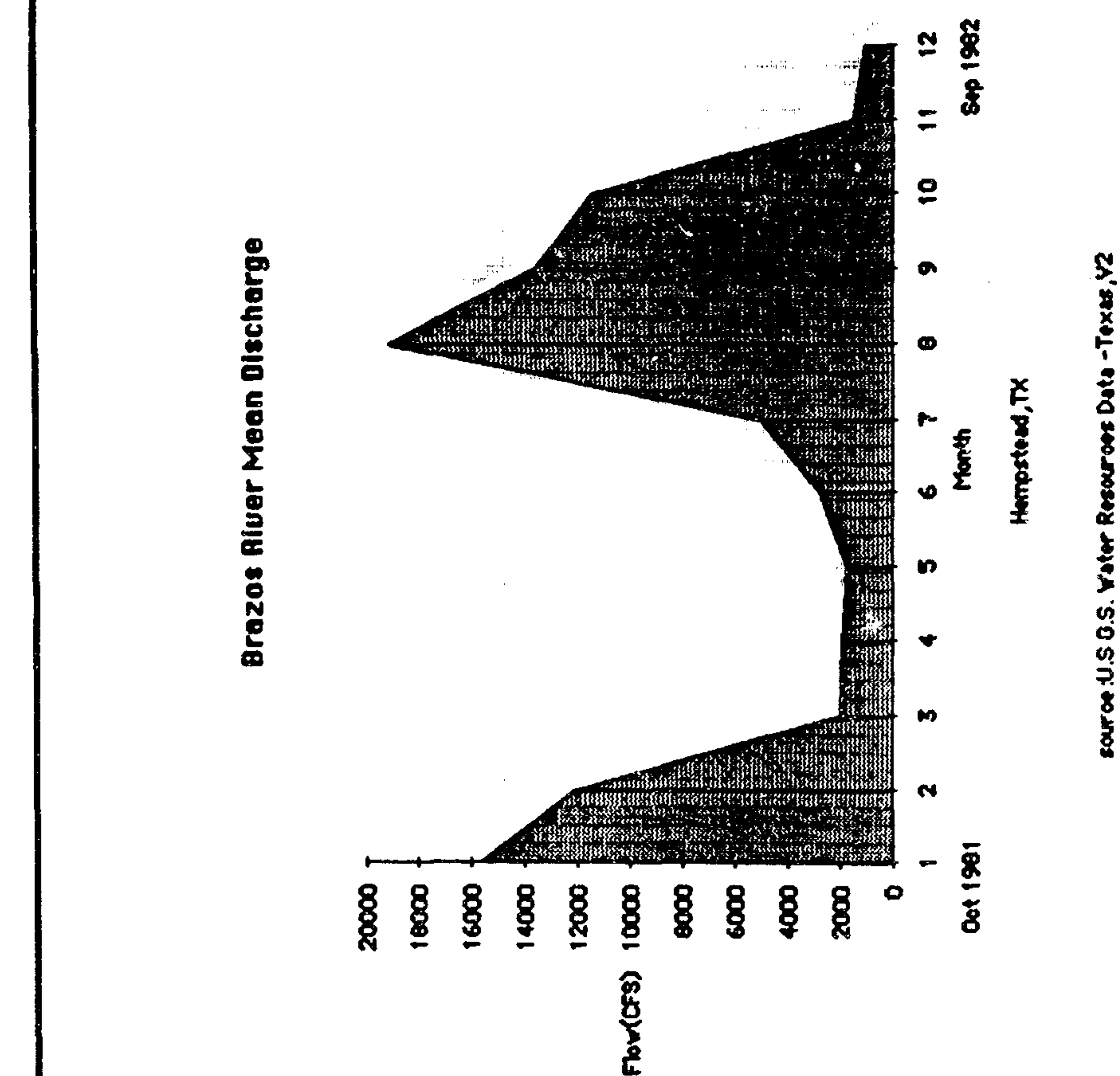


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FIGURE 5-2
BRAZOS RIVER MEAN DISCHARGE
HEMPSTEAD, TEXAS
SHERIDAN DISPOSAL SERVICE

DRAWN BY:	DATE:	PROJECT NO.

- Chloride - 300 ppm
- Sulfate - 200 ppm
- TDS - 750 ppm
- Dissolved Oxygen - $\geq$ 5.00 ppm
- Fecal Coliform - 200 per/100 ml
- Temperature - < 95°F

The TWC has classified the water quality of this river segment as generally good, with no significant water quality problems. Fecal coliform is the only significant parameter outside of the maximum loading as shown in the general water quality parameters listed in Table 5-1.

Table 5-1

Water Quality Information for Segment 1202 between 1979 and 1983

Parameter	Number of Samples	Minimum	Maximum	Mean
Dissolved Oxygen (mg/l)	15	4.3	13.5	8.8
Temperature (°F)	16	43.2	89.1	70.3
pH	13	7.0	9.1	8.0
Chloride (mg/l)	15	33	302	147
Sulfate (mg/l)	16	17	220	91
Total Dissolved Solids (mg/l)	16	182	853	525
Fecal Coliforms (#/100ml)	14	60	8000	446

Total dissolved solids were estimated by multiplying specific conductance by .61.

Source: The State of Texas Water Quality Inventory, 1984.

Water uses include contact and noncontact recreation, propagation of fish and wildlife, irrigation, and domestic raw water supply. The nearest downstream surface water permit for municipal drinking water use on the Brazos River is Freeport, Texas, located on the Gulf Coast.

5.1.2 Clark Lake - The SDS site is located near a cut bank on the Brazos River. Overland water runoff is away from the river into Clark Lake, which is a series of three shallow ponds formed by two man-made, earthen dams in a natural drainage channel. The pond system holds approximately 60 acre-feet of water and is located south of the pond and the evaporation system at the Sheridan site (Figure 5-3). The lake system has a total surface area of approximately 4.8 acres, while the central section within the two dams has an area of 3.45 acres.

As discussed in Section 5.3, Clark Lake discharges during high water stage into a drainage ditch that flows southwest into Donahoe Creek. Donahoe Creek is a small intermittent creek located south of the site (Figure 5.3). Donahoe Creek flows west and discharges into the Brazos River approximately five miles downstream of the SDS site.

5.2 Surface Water Investigations

5.2.1 Brazos River - In June of 1984, Resource Engineering Inc. obtained upstream and downstream samples of the Brazos River for GC/MS priority pollutant analysis; the results are summarized in Table 5-2. Details are provided in Appendix 5A.

Table 5-2

Priority Pollutant GC/MS Analysis

Brazos River Water

Compounds Detected	Concentration (ug/l or ppb) Upstream	Downstream
Volatile Fraction:		
Methylene Chloride	ND	BMDL* (<10)
Acid Fraction:		
Pentanoic Acid Ester	18	ND**
Base/Neutral Fraction:		
Bis (2-Ethylhexyl) phthalate	BMDL (<10)	BMDL (<10)

*BMDL - Identified at concentrations below method detection limits.

**ND - not detected.

The trace levels of methylene chloride and bis (2-ethylhexyl) phthalate are laboratory contaminants as evidenced by the positive laboratory blanks for each compound in the analytical data report. The lack of any downstream priority pollutant contaminants is evidence that the Brazos River is not impacted by contaminants from the site.

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5.2.2 <u>Clark Lake</u> - The earliest surface water quality data available for Clark Lake resulted from a Texas Department of Water Resources (TDWR) investigation. In response to a complaint, the TDWR inspected a fish kill in Clark Lake in March, 1978. TDWR investigations determined that the probable cause was anaerobic conditions resulting from an overflow of wastewater from a damaged cell in the evaporation system. Initial sampling and analysis indicated 5,000 to 6,000 mg/l COD and 2,000 to 2,500 mg/l TOC in Clark Lake.

According to a TDWR analysis, two weeks after the spill had occurred, the lake waters had a dissolved oxygen content of 0.5 mg/l. In reviewing the data, TDWR personnel considered the minimum level of dissolved oxygen necessary for maintaining a diverse ecosystem to be 2.0 mg/l. By May, 1978 TDWR testing indicated that the lake water COD had dropped to 1600 mg/l. Batch testing with an activated sludge "seed" and adequate aeration indicated that the organics were biodegradable to below 500 mg/l COD within 24 hours. Although the organics were rapidly biodegradable under laboratory conditions, the rate of breakdown in the lake was apparently slower. TDWR monitoring indicated the lake system remained anaerobic through January 1979.

At the request of the TDWR, Resource Engineering conducted an aquatic biota survey of the Clark Lake system in September, 1984. The report "Aquatic Survey of Clark

Lake at Sheridan Disposal Service" was submitted to EPA Region VI in October, 1984. The study showed that Clark Lake was supporting an active and diverse aquatic ecosystem and had recovered from earlier anaerobic conditions. Measurements of dissolved oxygen levels indicated supersaturated conditions. These high levels were probably due to algae photosynthesis. GC/MS analysis of a water sample indicated no detectable levels of priority pollutants and revealed no significant nonpriority organics present (Appendix 7C).

Sediment samples of Clark Lake were obtained in December, 1985 in response to an EPA request for additional site data. Three samples were obtained using a Peterson dredge on December 19, 1985 (Figure 3-2). The samples were analyzed by GC/MS techniques for priority pollutant compounds including pesticides and PCBs and selected degradation compounds of substituted aromatics. The results are summarized in Table 5-3.

Methylene chloride has not been detected in prior GC/MS analysis of impoundment wastewater or in significant quantities in the impoundment sludge. The trace levels of methylene chloride are present as a laboratory contaminant. The laboratory analysis blank sample contained trace amounts of methylene chloride and the spike recovery data was considered invalid due to high initial levels in the spiked sample. Methylene chloride is a common laboratory solvent; detection at this level represents laboratory background, considering the QA/QC data.

<u>Table 5-3</u>

Priority Pollutant GC/MS Analysis

Clark Lake Sediments

	Concentration (ug/kg or ppb_w)		
	Sample Location:		
Compounds Detected	L1	L2	L3
Volatile Fraction:			
Methylene Chloride	20.6	ND**	ND
Acid Fraction:			
Benzoic Acid	BMDL* (<360)	ND	ND
Base/Neutral Fraction:			
Di-n-butyl phthalate	890	ND	ND
Pesticide/PCB:	ND	ND	ND

*BMDL - Tenatively identified at concentrations below method detection limits

**ND - Not detected

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Benzoic acid is one of four degradation compounds of substituted aromatics identified in the pond sludge. Benzoic acid tentatively found below detection limits in one sample of the sediment further supports the hypothesis that Clark Lake has recovered from prior spill contamination through biodegradation of organics.

Di-n-butyl phthalate is present at less than 1 ppm (890 ppb) in the sample. This compound is used as an insect repellent and also is a common plasticizer compound. The QA/QC data for this analysis indicated a 177% recovery on a spiked sample which is questionably high. Since this compound has not been detected in prior organic analysis of the impoundment sludge or wastewaters, its presence as a contaminant from pond waters is unlikely.

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Overall, the sediment analysis indicated that Clark Lake has not been permanently impacted by the prior wastewater spill and fish kill, and that insignificant levels of degradation products remain in lake sediments.

5.3 <u>Surface Hydrology</u>

5.3.1 <u>General Setting</u> - The high bank of the Brazos River forms the northern boundary of the Sheridan property at an approximate elevation of 172 MSL (mean sea level) as shown in Figure 5-3. The land surface slopes south and southwest, away from the river at a rate of approximately 8 feet per mile.

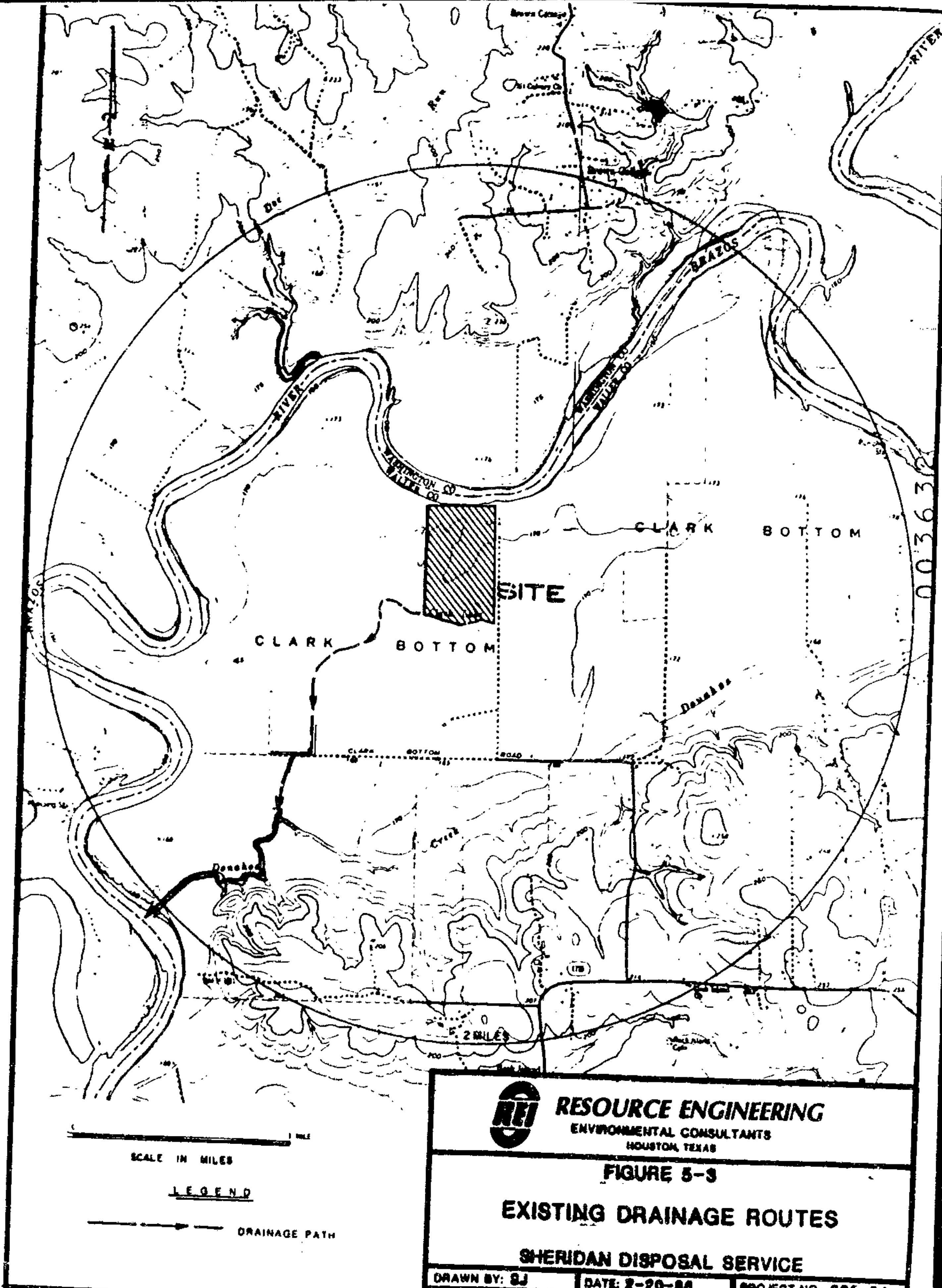

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FIGURE 5-3

EXISTING DRAINAGE ROUTES

SHERIDAN DISPOSAL SERVICE

DRAWN BY: SJ	DATE: 2-20-86	PROJECT NO.: 285-04
CHK'D BY:	REVISED:	DWG.NO.:

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Drainage from the northern portions of the site is poorly developed. As shown in Figure 5-3, stormwater generally flows south from the disposal site to Clarke Bottom Road; then it flows west along Clarke Bottom Road to a main drainage ditch, which flows south to Donahoe Creek. Donahoe Creek flows southwest and discharges into the Brazos River approximately one mile southwest of the Sheridan property. Within this drainage pattern is Clark Lake.

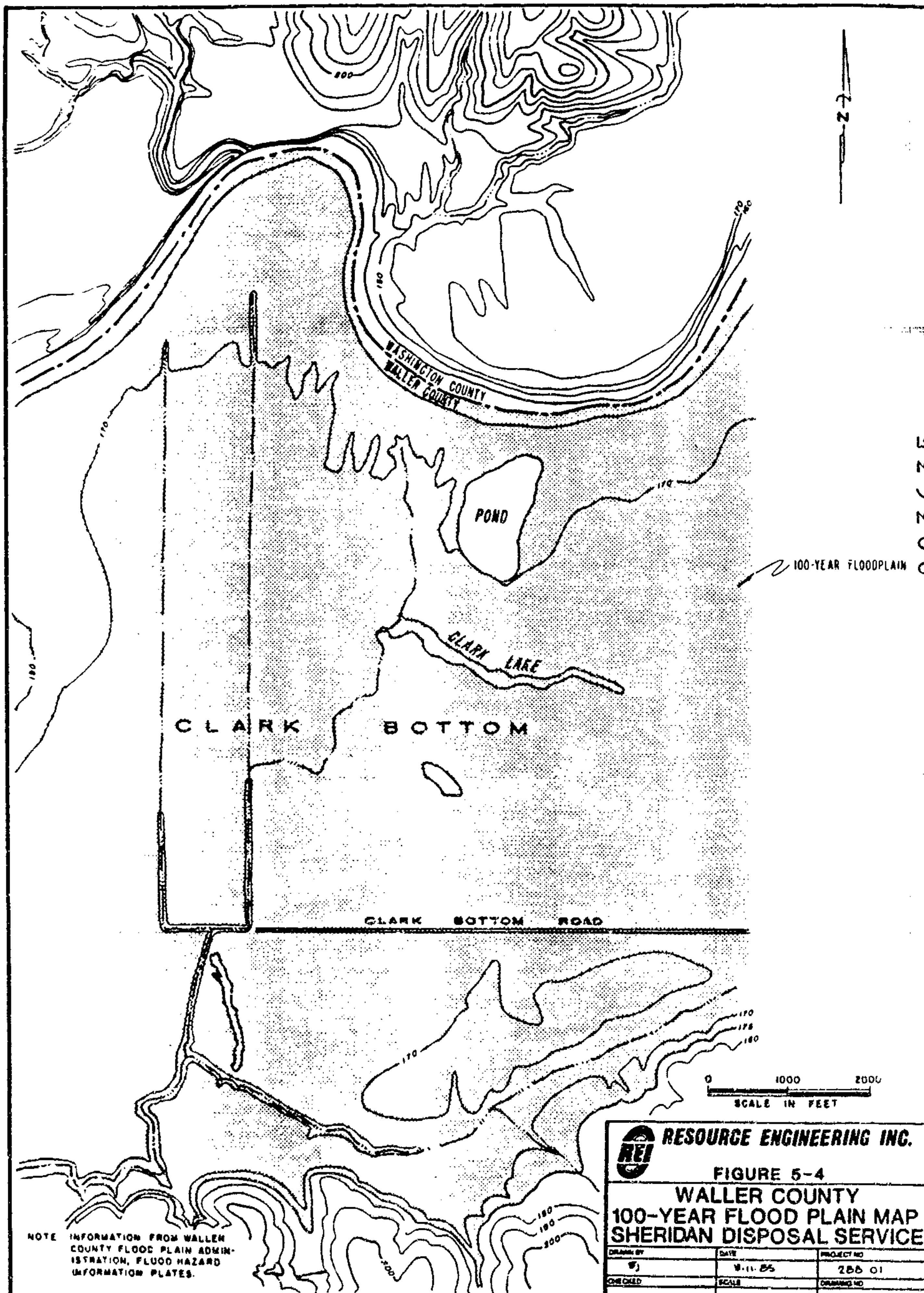
Much of the stormwater runoff from the uncontaminated area drains from the property through Clark Lake by sheet flow or via the drainage ditch along the eastern site access road, and then south to Donahoe Creek. As of May of 1987, the pond impoundment and the evaporation system had adequate freeboard to contain the precipitation from the 24-hour, 100-year storm (11.9 inches) falling within these areas which could potentially become contaminated.

5.3.2 Floodplain Conditions - Natural site elevations, based upon USGS topographic maps, vary from approximately 173 feet above MSL along the river to 165 feet along Clarke Bottom Road. The lowest point on the top of the pond dike is approximately 176.5 feet above MSL.

The Corps of Engineers developed an analysis of the 100-year flood elevation for the area as part of a study for the proposed Millican Lake project to be located on the Navasota River. In this study, flood elevations were established by computer modeling of the entire Brazos River and its tributaries, calculating backwater elevations at various cross-sections along the river for the 100-year flood flow. One of the cross-sections developed in this study intersects the eastern portion of the SDS site. A copy of this cross-section establishing a 100-year flood plain elevation of 175 feet above MSL at the site is contained in Appendix 5B. Figure 5-4 illustrates the flood plain based on these data.

The 175-foot flood plain elevation was used in assessing flood plain impacts upon the site. Based upon these data, existing pond dikes are a minimum of 1.5 feet above the 100-year flood plain elevation and should be adequate to prevent inundation of the wastes by a 100-year flood event. The remainder of the site, including the evaporation system, would be inundated by the 100-year flood. During a major flood event, the flow pattern should follow the major drainage pattern of the Brazos River, which is to the south.

One concern relative to flood protection provided by pond dikes is the possible dike erosion during a major flood. As shown on the cross-section in Appendix 5B, the river channel is over 50 feet deep, and would contain a major portion of the flood flow. In addition, the extremely broad flood plain width at the site location, together with a minimal water depth above the south bank of the Brazos would preclude any high water velocities within the overbank flow. The resulting "scour velocity" acting on the pond dikes would be on the order of only



NOTE INFORMATION FROM WALLER COUNTY FLOOD PLAIN ADMINISTRATION, FLOOD HAZARD INFORMATION PLATES.

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FIGURE 5-4

WALLER COUNTY
100-YEAR FLOOD PLAIN MAP
SHERIDAN DISPOSAL SERVICE

DRAWN BY	DATE	PROJECT NO
WJ	9-11-85	288 01
CHECKED	SCALE	DRAWING NO

003635

two to three feet per second (Appendix 5B). These velocities would not produce significant erosional effects (The Texas Highway Department, 1970).

Recorded observations by TDWR indicate that, in 1979, when the Brazos overflowed its banks at the site, there was no pond dike damage. This supports the projected negligible impact of dike erosion due to flood waters at the site.

5.3.3 Stormwater Runoff - Stormwater runoff was calculated to determine the peak flow and total runoff volume from a 100-year, 24-hour storm of 11.9 inches. The runoff quantities obtained assume that the storm is localized, since a broad based 100-year storm would cause water to overtop the Brazos River banks and, consequently, to inundate the entire site as described previously.

The calculations were performed using the Soil Conservation Service (SCS) TR-55 chart method, and by computer modeling using the SCS TR-55 graphical method (Appendix 5C). The areas and calculation points used are shown on Figure 5-5. The results were as follows:

Calculation Points	Contributing Areas	Peak Flow (CFS) 100-Yr, 24-Hr	Total Runoff (Acre-Ft)
1	I & II	97	30.5
2	I, II & V	92	33.55
3	III	73	27.54
4	III & IV	63	30.79

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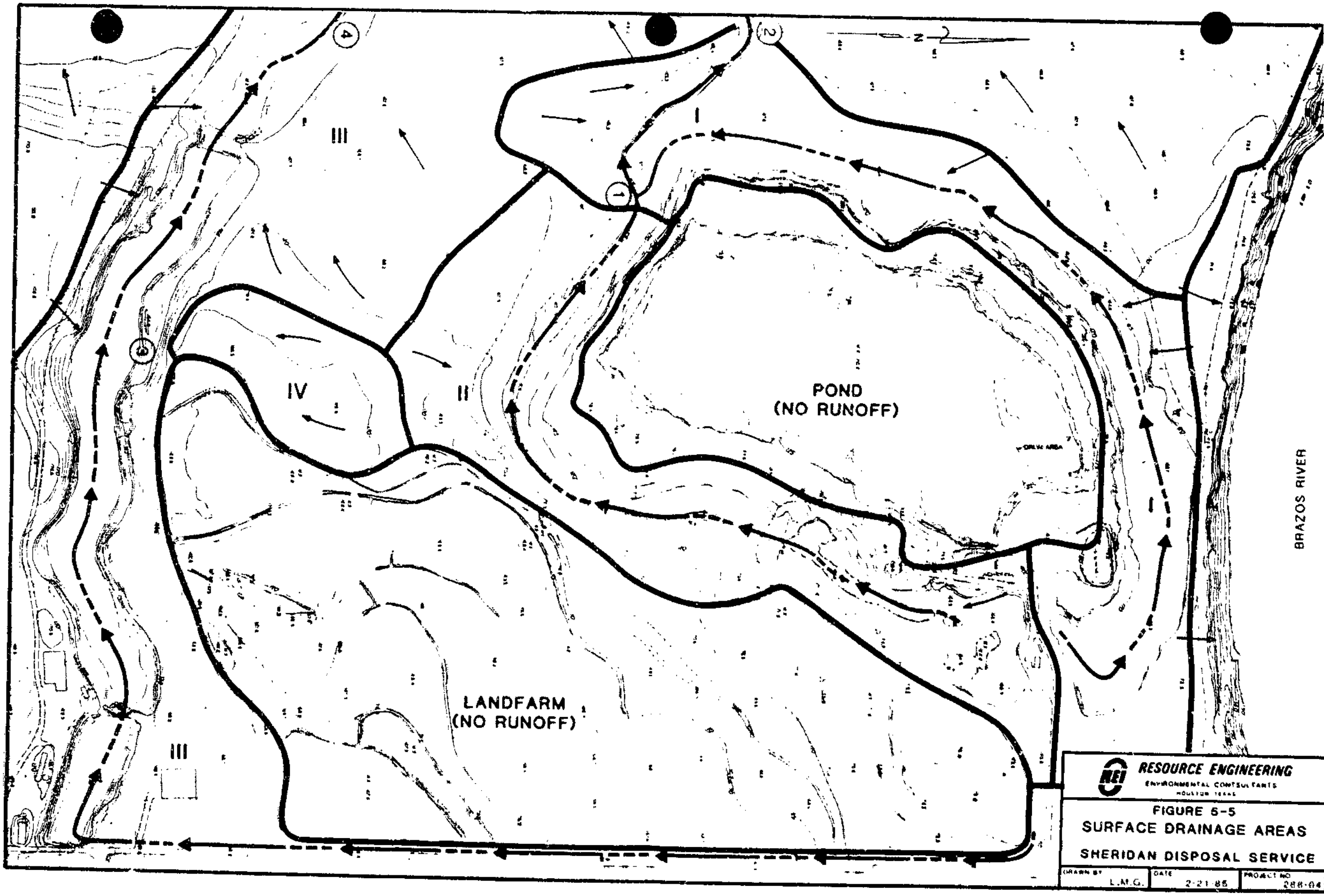

III
I
IV
II
POND
(NO RUNOFF)
LANDFARM
(NO RUNOFF)
III
BRAZOS RIVER
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FIGURE 6-5
SURFACE DRAINAGE AREAS
SHERIDAN DISPOSAL SERVICE
DRAWN BY L.M.G.
DATE 2-21-85
PROJECT NO. 288-04

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5.3.4 On-Site Stormwater Storage - Two areas, the evaparative system and the pond, will store rainwater and will not contribute to stormwater runoff. Calculations were performed to determine the average yearly water volume increase or decrease in the pond and evaporation system areas (Appendix 5C). Rainfall data was taken from "Soil Survey of Austin and Waller Counties" published by the Soil Conservation Service and evaporation data from "Monthly Reservoir Evaporation Rates for Texas 1940 Through 1965" published by the Texas Water Development Board.

The net precipitation onto these two areas was assumed to equal the yearly average precipitation less the yearly average evaporation. In general, the evaporation exceeded the rainfall so that there is net decrease in water volume. However, in the pond area, due to an oil film on the surface of the water, evaporation rates were assumed at worst case to be decreased by fifty percent (50%). This yielded a net water volume increase in the pond of 6.8 million gallons per year (910,000 cubic feet per year). Based on this datum and the aerial survey of the site (Figure 5-5), the pond can be expected to store all precipitation falling within the dikes for approximately four (4) years from the date of the survey (July, 1984).

The data were then examined to determine a "worst case" monthly net rainfall. As can be seen from the data in Appendix 5C, the highest net rainfall of 0.83 inches typically occurs in February. Using the previously discussed evaporation constraints, the results were a net water volume increase in the pond of 1,200,000 gallons (162,000 cubic feet) and in the evaporation system of 890,000 gallons (119,000 cubic feet). These estimates will be used in sizing stormwater management facilities during feasibility studies of remedial actions and also for evaluating the impacts of stormwater runoff in a no-action alternative.

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6.0 AIR INVESTIGATIONS

6.1 Summary - The following ambient air quality conclusions at the Sheridan Disposal site are based on independent sampling and analysis by Resource Engineering and the EPA's Emergency Response Team in March, 1986:

- The site has no detectable volatile emissions of polychlorinated biphenyls (PCBs), based on detection limits of 0.003 mg/m^3 at average annual, ambient weather conditions.
- The site has no detectable emissions of volatile RCRA Hazardous Substance List organic compounds above background levels or listed RCRA hazardous substances during average annual ambient weather conditions.

6.2 Introduction - The purpose of Chapter 6 is to evaluate present air quality impacts based on emissions from the site. The feasbility study will address the impacts of disturbing the sludge during response actions. The most comprehensive air survey of the site was conducted on March 4 and 5, 1986 by the EPA's Emergency Response Team and Resource Engineering. The Emergency Response Team collected 88 air samples at 20 locations. The samples were collected using 200

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mg Tenax tubes for low-level organics; 150 mg carbon tubes for high-level organics; and 150 mg Fluorosil tubes for polychlorinated biphenyls (PCBs) analysis.

Resource Engineering collected 24 samples from 14 locations. The Resource Engineering samples were collocated with EPA sample locations where possible to independently verify results. Another objective of the Resource Engineering sampling was to determine the average off-site impacts at the property boundaries and incorporate this information into the risk assessment for the site. Background ambient air quality is represented by upwind sample results for each individual sampling event.

In July, 1985 an EPA Field Investigative Team conducted an air monitoring survey of the site. Two HNu PI-101 photoionization detectors were used to screen for total hydrocarbon levels. The results were negative with no hydrocarbons detected above background levels of 0.2 ppm (Appendix 6A). These results are consistent with results of HNu surveys conducted by Resource Engineering in 1985 and early 1986.

The first air investigations of the site were conducted in July, 1983 by an EPA Field Investigative Team. During the site investigation of July 12, 19, and 20, 1983, a series of 18 ambient air samples were collected using Tenax absorption tubes. Analysis of the samples through thermal desorption and Gas Chromatographic/Mass Spectrometry (GC/MS) techniques

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indicated total levels of volatile organics ranged from 8 to 427 ppm. This data has been invalidated by the EPA due to positive field blanks and the lack of a true background upwind sample. Due to the absence of acceptable data, the EPA scored the air route zero in the Hazardous Waste Site Ranking package for the Sheridan Disposal Services site.

Additionally, the volatile organic concentration values reported in the July 1983 sampling exceeded the absorptive capacity of standard 200 mg Tenax tubes at the volumetric flow rates and durations sampled.

6.3 Sampling Procedures and Conditions - The March 4 and 5, 1986 Resource Engineering samples were obtained using DuPont ALPHA 1 air sampling pumps. The pumps were pre- and post-calibrated on-site for each sampling run. Tenax sample tubes in the pond area were followed by carbon tubes as protection against breakthrough due to oversaturation of organics. Samples at each location were collected in duplicate at volumetric flow rates of 50 cc per minute and 200 cc per minute for a 1-hour period. A complete description of sampling procedures including schematics of sampling equipment is included in Appendix 6B.

The March 4 and 5, 1986, EPA sampling periods were 40 minutes for the Tenax tubes and 360 minutes for the carbon and Fluorosil tubes. Sampling volumetric flow rates were 50 cc/minute for the Tenax samples and 500 cc per minutes for the carbon and Fluorosil tubes. Additional available information on EPA sampling procedures is contained in Appendix 6C.

On March 4, 1986, the EPA Emergency Response Team conducted two sampling runs at 13:15 and 16:15 hours. Weather conditions consisted of temperatures ranging from 58 to 76°F, and winds of 10 to 15 mph with gusts of 20 mph from the north-northwest to west. Resource Engineering laboratory analysis was limited to the second set of samples, since the higher ambient temperatures represented worst case emissions for the day. Figure 6-1 shows the locations of sampling stations for the 16:15 sampling event.

Upwind (background) sample locations for the March 4, 1986 sampling event were REI UWB1, UWB2, and EPA Station #1 which were located northwest of the pond from 100 to 350 feet from the Brazos River. EPA station #3 was located next to a spill area close to the existing storage/separation tanks in the northeast section of the pond berm. EPA stations #4 and #5 were located within 10 feet of the pond's eastern shoreline. EPA station #6 was located on the southern end of the pond less than six inches above surface floating oil. The sample at this location was a 6-hour Fluorosil and carbon tube pair. REI samples DWB3 and DWB4 were colocated with EPA sample stations #6A and #7, respectively. EPA station #8 was located 12 feet from the pond in the middle of the southern shoreline. REI sample station DWB5 was located downwind at the southern property boundary near monitoring well #12.

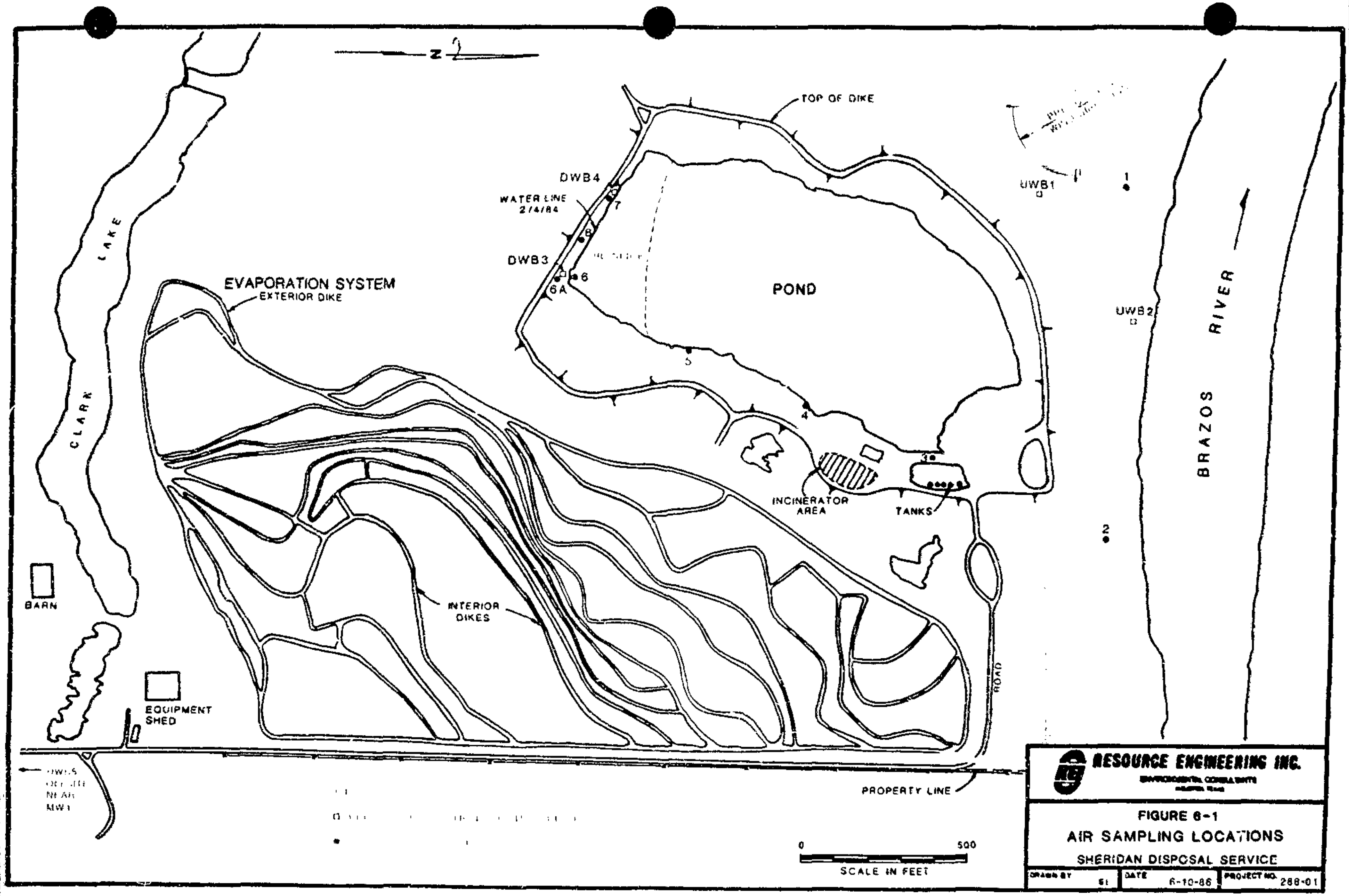
N
TOP OF DIKE
DWB4
WATER LINE
2/4/84
7
8
DWB3
6
6A
POND
5
4
3
UWB1
1
UWB2
2
BRAZOS RIVER
CLARK LAKE
EVAPORATION SYSTEM
EXTERIOR DIKE
INTERIOR DIKES
INCINERATOR AREA
TANKS
ROAD
BARN
EQUIPMENT SHED
PROPERTY LINE
0
500
SCALE IN FEET
RESOURCE ENGINEERING INC.
FIGURE 6-1
AIR SAMPLING LOCATIONS
SHERIDAN DISPOSAL SERVICE
DATE 6-10-86
PROJECT NO. 288-01

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Figure 6-2 shows the location of sample stations during the March 5, 1986 15:15 sample series. The upwind (background) sample stations are REI UW#1 and UW#2 which were collocated with EPA stations #11 and #10, respectively. REI sample station DW4 was collocated with EPA station 15A in the northeast corner of the pond within 10 yards of the pond shoreline. REI sample station DW5 was collocated with EPA station 16 in the northwest section of the pond shoreline. REI sample station DW2 was located downwind at the property boundary on the bank of the Brazos River.

The weather conditions for March 5, 1986 were temperatures in the 63° to 77° range with winds of 5 to 15 mph from the south-southwest and gusts up to 20 mph.

6.4 Results - One important distinction between ambient air sampling and soil sampling is the definition of background concentration levels. Without an extensive data-base background is defined by upwind sample concentrations for the particular sampling event. Air quality measurements taken without upwind samples for comparison cannot be evaluated since background cannot be defined. This is especially significant for the Sheridan site, since all ambient air measurements are in the 1 to 10 ppb range, the limit of detection for GC/MS analysis. Oil and gas production and drilling activities can significantly impact low ppb levels of benzene, toluene and xylene, specifically. As discussed previously, background

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concentration levels are defined by the following upwind samples:

March 4, 1986 Sampling Event:

REI - Sample # UWB1, UWB2

EPA - Sample Station #1

March 5, 1986 Sampling Event:

REI - Samples # UW#1, UW#2

EPA - Sample Stations #10, 11

Analytical results are contained in Tables 6-1 and 6-2 for both Resource Engineering and EPA samples. Results of EPA analysis for both days indicated no detectable levels of polychlorinated biphenyls (PCBs) in any of the Fluorosil samples. The detection limit for PCBs in air was 0.003 mg/m^3. Also, no detectable levels of organic vapors were found in the carbon tube samples, except for a background sample at an upwind station (#10). The detection limits for organics using carbon adsorption analysis varied from 0.008 ug/m^3 to 0.02 ug/m^3 which corresponds to 7 ppb_w to 169 ppb_w (Table 4, Appendix 6-C). Considering several carbon tubes were located only inches above the pond surface, the results conclusively indicate that no RCRA hazardous substance list compounds were emitted from the pond.

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No RCRA Hazardous Substance List compounds were detected at quantifiable levels for any of the Resource Engineering samples except for acetone in one upwind background sample (UW2)(Table 6-1). In general, the results indicate ambient air quality of the site is better than ambient air quality of the urban Houston area.

To evaluate the posibility of introducing laboratory contaminants, first an analysis of field and laboratory method blanks must be done. The REI laboratory method blank was analyzed to have positive results for chloromethane, acetone, 2-butanone, cis-1,3-dichloropropene, and toluene. Trace amounts of these compounds in other samples represent laboratory contamination or Tenax adsorbent degradation products. The field blank contained trace levels of chloromethane and 2-butanone. The majority of these compounds were also found in the trip blanks. The only compound found in trace amounts in REI data not accountable by field or method blanks was benzene in samples DWB3 and DWB4. These trace levels are well under ambient concentrations of benzene found naturally and comparable to EPA results for the March 4, 1986 site background level of benzene (1.6 ppb).

As Tables 6-2 and 6-3 indicate, the results of EPA sampling for March 4 and 5 were that no hazardous substance list volatile compounds were found above site background concentration levels. EPA sample results did indicate trace quantities of various RCRA Hazardous Substance List compounds.

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However, trace Below Method Detection Limits (BMDL) results are not reportable quantities. Trace results are less than site background and are from four to seven orders of magnitude less than TLV-TWA health impact values.

The results of the EPA March 4, 1986 sampling (Table 6-2) indicate all of the reported toluene values are within 1 ppb of background; all of the reported benzene values are within 2.5 ppb of background and all of the reported xylene values are less than background with the exception of sample 6A which was 0.6 ppb above background. The EPA analytical report stated the aromatic standard recovery at this low concentration level of analysis was unacceptable and varied from -9% to 40% for benzene and -60% to 78% for ethylbenzene (Appendix 6C). The results of these analyses are all within analytical error limits of background.

The results of the EPA March 5, 1986 sampling indicate benzene, toluene and xylene are less than background concentrations in all samples (Table 6-3). Positive results for methylene chloride in samples 125 and 145 represent laboratory contamination, since the corresponding duplicate tubes found only BMDL levels. Methylene chloride was also found in the field and trip blanks.

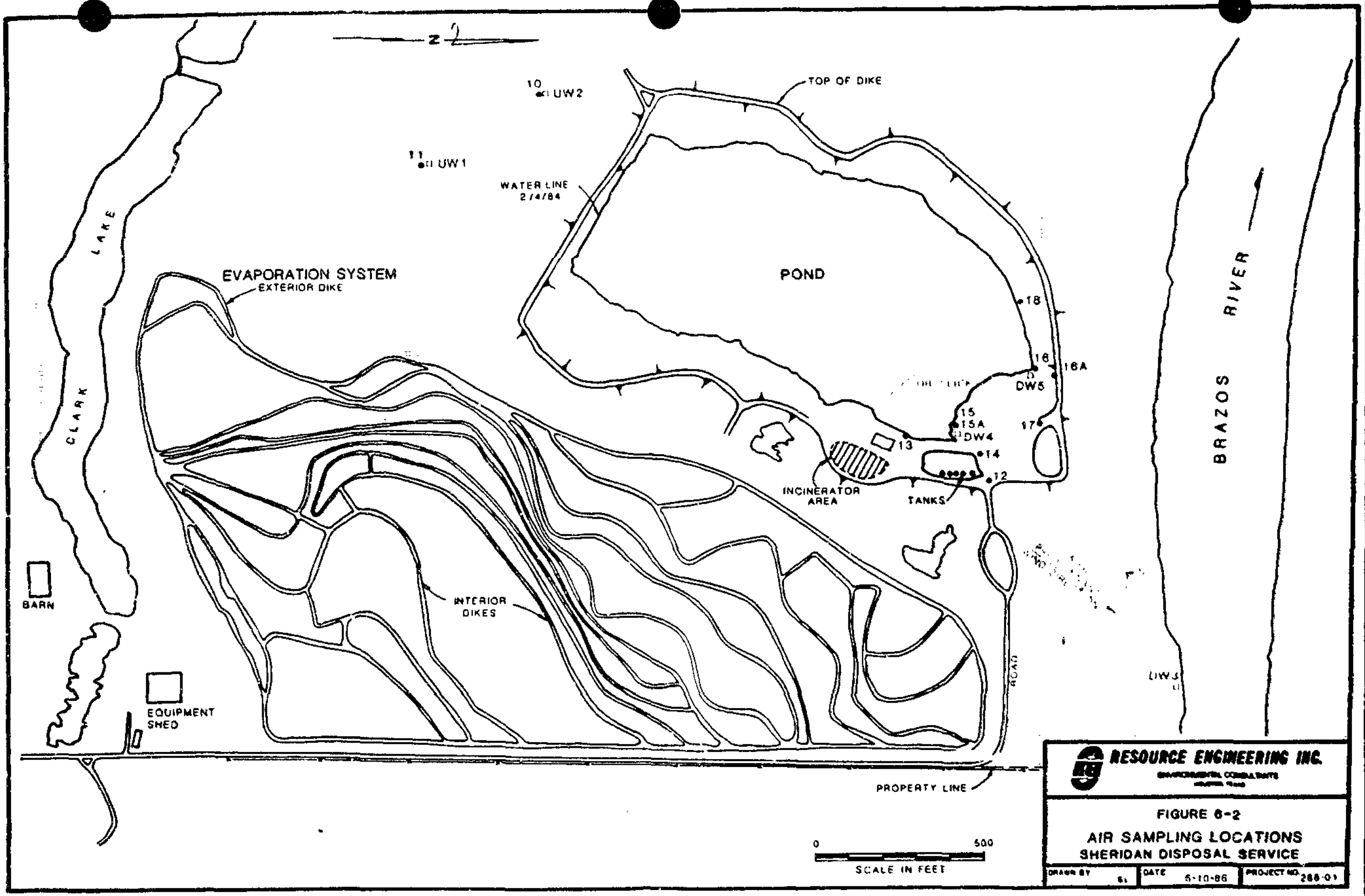

FIGURE 6-2

AIR SAMPLING LOCATIONS

SHERIDAN DISPOSAL SERVICE

DRAWN BY	DATE	PROJECT NO.
	5-10-86	288-01

Table 6-1

Air Monitoring Results
(REI Data 3/4 and 3/5 1986)

Sample Concentration ppb Volumetric Basis

Hazardous Substance List Volatile Compound	Method Blank	Field Blank (3/4/86)	UWB2 (BK.)	DWB3	DWB4	DWB5	Field Blank (3/5/86)	UW2 (BK.)	DW3	DW4	DW5
Field ID (4909)	-	19	23	27	24	29	40	33	31	39	36
Lab ID	33885	34067	34048	34058	34049	34053	34069	490933	34055	34064	34067
Chloromethane	BMDL	BMDL	BMDL	BMDL	BMDL	BMDL	BMDL	ND	BMDL	BMDL	BMDL
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND	BMDL	ND	ND	ND
Methylene Chloride	ND	ND	ND	BMDL	ND	ND	ND	BMDL	ND	ND	ND
Acetone	BMDL	ND	ND	ND	ND	ND	ND	2.7	ND	ND	ND
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Butanone	BMDL	BMDL	BMDL	BMDL	ND	BMDL	BMDL	ND	BMDL	BMDL	BMDL
1,1,1-trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Acetate	ND	ND	ND	BMDL	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

BMDL - Tentatively identified at levels below method detection limits
N/D - Not detected
BK - Blank

Table 6-1 (Continued)

Air Monitoring Results
(REI Data 3/4 and 3/5 1986)

Sample Concentration ppb Volumetric Basis

Hazardous Substance List Volatile Compound	Method Blank	Field Blank (3/4/86)	UWB2 (BK.)	DWB3	DWB4	DWB5	Field Blank (3/5/86)	UW2 (BK.)	DW3	DW4	DW5
Field ID (4909)	-	19	23	27	24	29	40	33	31	39	36
Lab ID	33885	34067	34048	34058	34049	34053	34069	490933	34055	34064	34067
Benzene	ND	ND	BMDL	BMDL	BMDL	ND	ND	BMDL	BMDL	BMDL	ND
CIS-1,3-Dichloropropene	BMDL	ND	ND	ND	BMDL	BMDL	ND	BMDL	BMDL	BMDL	ND
2-Chloroethyl Vinyl Ether	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-Pentanone	ND	ND	ND	ND	ND	ND	ND	BMDL	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	BMDL	ND	ND	BMDL	ND	ND	ND	BMDL	BMDL	BMDL	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
M-Xylenes	ND	ND	ND	ND	ND	ND	ND	BMDL	ND	ND	ND
O&P-Xylenes	ND	ND	ND	ND	ND	ND	ND	BMDL	ND	ND	ND

BMDL - Tentatively identified at levels below method detection limits
N/D - Not Detected
BK - Blank

RESOURCE ENGINEERING

Table 6-2

Sheridan Disposal Service
Air Monitoring Results
(EPA Data 3/4 1986)

Sample Concentration ppb Volumetric Basis

Compound Sample Station # Lab Reference #	Field Blank 24301	Trip Blank 24264	1(BK.) 24284	3 24272	4 24273	6 24274	6A 24280	8 24281
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	BMDL	ND	BMDL	ND	ND	ND	BMDL	BMDL
Methylene Chloride	0.6	BMDL	BMDL	ND	BMDL	ND	BMDL	ND
Trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND
1,1,-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	1.2	BMDL	1.2	7.7	2.8	BMDL
1,2 Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	1.3	1.4	1.6	1.7	1.9	2.3	3.7	1.8
Carbon Tetrachloride	ND	ND	BMDL	BMDL	BMDL	ND	BMDL	BMDL
Trichloroethene	ND	ND	ND	ND	ND	BMDL	ND	ND
Toluene	2.2	1.3	2.9	1.8	3.4	3.2	3.9	1.4
Tetrachloroethene	ND	ND	ND	ND	ND	BMDL	BMDL	ND
Ethyl Benzene	BMDL	BMDL	BMDL	0.6	BMDL	BMDL	0.5	BMDL
Xylene	1.3	BMDL	1.1	1.1	1.2	1.3	1.9	0.6

BMDL - Tentatively Identified At Levels Below Detection Limits
N/D - Not Detected
BK - Blank

Table 6-3

Sheridan Disposal Service
Air Monitoring Results
(EPA Data 3/5 1986)

Sample Concentration ppb Volumetric Basis

Compound / Sample Station # / Lab Reference #	Field Blank 24301	Trip Blank 24264	Background: Upwind K Tube 24297	Background: Upwind Supelco 24299	12K 24286	12S 24285	13K 24289	14K 24291	14S 24290	15AK 24293	16K 29294
Vinyl Chloride	ND	ND	ND	BMDL	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	BMDL	ND	ND	BMDL	ND	ND	ND	ND	BMDL	ND	ND
Methylene Chloride	0.6	BMDL	BMDL	BMDL	BMDL	5.8	ND	BMDL	8.7	BMDL	ND
Trans-1,2,-Dichloroethene	ND	ND	ND	BMDL	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	BMDL	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	BMDL	BMDL	BMDL	BMDL	ND	BMDL	BMDL	BMDL	BMDL
1,2 Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	1.3	1.4	4.0	2.5	1.9	1.4	1.8	1.2	1.2	2.1	1.1
Carbon Tetrachloride	ND	ND	ND	ND	ND	ND	ND	BMDL	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	2.2	1.3	4.6	2.0	1.6	0.8	1.4	3.6	0.8	1.6	1.0
Tetrachloroethene	ND	ND	ND	ND	ND	BMDL	ND	ND	ND	ND	ND
Ethylbenzene	BMDL	BMDL	BMDL	BMDL	0.8	0.5	BMDL	0.8	BMDL	BMDL	BMDL
Xylene	1.3	BMDL	3.8	2.2	1.3	0.9	0.5	1.0	0.8	0.9	1.1

BMDL - Tentatively identified at levels below detection limits
N/D - Not Detected
BK - Blank

As Tables 6-1 and 6-2 and 6-3 indicate, the ambient air quality results were virtually the same for both days despite a 180° change in wind direction. No EPA Hazardous Substance List compounds were detected above background levels by either REI or EPA analysis.

Table 6-4 is a comparison of Houston urban area mean background and OSHA Threshold Limit Values (TLV) for the RCRA Hazardous Substance List compounds. Although the SDS site is a rural area and Houston is an urban area, the Houston data is the only available regional data which is a statistical representation of background gathered from sampling over a multi-year period. Houston residents are exposed to ambient air which has toxic air pollutants at concentration levels at least twice the levels at the Sheridan site.

The field sampling program was conducted during a period when daily temperatures ranged from 63° to 77°F. Although these temperatures are representative of mean annual conditions, maximum emission rates would occur during summer months when daily temperatures are higher. The emission rates of organic compounds are linearly related to the compound's vapor pressure, which increases with increasing temperature. The increase in emission rates due to summer temperatures are therefore proportionally related to the increase in vapor pressure of the specific organic compounds. Table 6-5 shows the increase in vapor pressure from 70° to 90°F for the major volatile organic compounds found in the sludge.

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Table 6-4

Houston Area Background Levels and TLV Values Concentrations in ppb Volumetric Basis

Hazardous Substance List Volatile Compound	Houston Area Mean Background[1] (5/14-5/25 1980)	OSHA TLV-TWA
Chloromethane	1.0	50,000
Bromomethane	0.1	5,000
Vinyl Chloride	5	5,000
Chloroethane	0.2	1,000,000
Methylene Chloride	NA	100,000
Acetone	NA	750,000
Carbon Disulfide	NA	10,000
1,1-Dichloroethene	0.03	5,000
1,1-Dichloroethane	0.06	200,000
Trans-1,2-Dichloroethene	NA	200,000
Chloroform	0.4	10,000
1,2-Dichloroethane	1.5	10,000
2-Butanone	NA	200
1,1,1-trichloroethane	0.4	350,000
Carbon Tetrachloride	0.4	5,000
Vinyl Acetate	NA	10,000
Bromodichloromethane	NA	-
1,2-Dichloropropane	0.08	75,000
Tans-1,3-Dichloropropene	NA	-
Trichloroethene	0.1	50,000
Dibromochloromethane	NA	-
1,1,2-Trichloroethane	0.03	10,000
Benzene	5.8	10,000
CIS-1,3-Dichloropropene	NA	-
2-Chloroethyl Vinyl Ether	NA	-
Bromoform	0.01	5,000
2-Hexanone	NA	5,000
4-Methyl-2-Pentanone	NA	-
Tetrachloroethene	0.4	50,000
1,1,2,2-Tetrachloroethane	0.01	1,000
Toluene	10.3	100,000
Chlorobenzene	NA	75,000
Ethylbenzene	1.4	100,000
Styrene	NA	50,000
M-Xylenes	3.8	100,000
O&P-Xylenes	1.3	100,000

N/A = Not available
\- = No standard
1 = Source Measurement of Hazardous Organic Chemicals in the Ambient Atmosphere EPA-600 53-83-002, March 1983.

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TABLE 6-5

VAPOR PRESSURES OF SIGNIFICANT VOLATILE ORGANIC COMPOUNDS

	VAPOR PRESSURE (in PSIA)		
	@ 70°F	@ 90°F	% Change
Benzene	1.53	2.54	66.0
Ethylbenzene	0.15	0.28	86.7
Toluene	0.45	0.79	75.6

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Overall, the March 4 and 5, 1986 ambient air sampling survey generated a very high quality level of data which was verified through independent sampling and analysis. The data are representative of average ambient air quality of the site and indicate the site has no impact on local air quality.

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7.0 BIOTA INVESTIGATIONS

7.1 Introduction - This chapter presents the results of an ecological survey of the Sheridan Disposal Services (SDS) site and the surrounding area. An inital survey was conducted in January and February of 1986; a follow-up survey was done in June, 1986. Complete copies of the ecological surveys are found in Appendices 7A and 7B.

The objectives of the surveys were to:

- prepare an inventory of plants and animals on the Sheridan Disposal Services site, including the Sheridan property and the adjacent property east of the entrance road;
- assess the ecological condition of the property and the current or potential ecological stresses on the flora and fauna; and
- investigate specifically the presence and status of endangered plant and animal species and assess any critical habitats of those species.

All areas and microhabitats of the site and adjoining property, a total of approximately two square miles, were surveyed. An extensive catalog of the site's plant and animal species, including population densities and taxa, can be found in Appendices 7A and 7B.

Floral and faunal diversity and distributions were evaluated by the site investigator who has performed field work in this region for 25 years (Appendix 7A, Section 4.1).

Sampling during the survey consisted of:

- collecting and identifying plant species;
- screening and identifying insect larvae from evaporation system sediments;
- live-trapping small mammals; and
- collecting and identifying insect invertebrates found under logs and in surface debris.

In addition to observations and samplings, mammal species and relative populations were determined by analyzing tracks found in the survey area. Most of the mammals expected in the region, based on the investigator's experience, were detected.

Seasonal ambient conditions during the winter survey influenced the species diversity greatly. Daytime temperatures ranged from 35 to 75 degrees F. Previous freezes had killed much of the emergent plant growth. Additional plant species were identified in June, 1986 (Appendix 7B).

Birds sighted in January-February, 1986 were those that normally inhabit the Upper Texas Coast in winter. Some are permanent residents, but many are present only during this season and move farther north in the spring. They, in turn, are replaced by other species that return to nest. Several nesting species were verified in June.

The number of insects and reptiles was also reduced during the winter season. Many spend the colder months in diapause or in hibernation, and are undetectable by surface surveys. Summer insect populations were particularly high, accompanied by a high species diversity. Terrestrial reptiles are severely limited on the site because of the lack of adequate ground cover due to cultivation and cattle grazing. This lack of cover also limits the number of small mammals.

Summarizing the results of the survey, the SDS site contains a number of different ecological habitats and a corresponding diversity of plant and animal species. These were cataloged and their relative numbers and conditions observed. The data compare favorably with area biological checklists and with regional field work carried out by the investigator over a 25-year period. Indeed, in many cases, numbers of species and individuals were particularly high.

No detrimental effects on the flora and fauna from the presence of wastes were detected, except for their occasional physical contact with floating oil in the disposal pond. Plant species were as diverse and as abundant in the immediate vicinity of the disposal system as in the more distant areas of the survey tract. None showed evidence of biocontamination as reflected by abundance, stature, foliar condition, flowers, or fruits. They also supported high

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concentrations of birds and insects (Appendices 7A, Section 7.2.1; 7B, Section 5.1).

Insects of several orders were abundant during the June survey (Appendix 7B, Section 6.5); many species were observed in all stages of development and metamorphosis. No disruption of normal development was noted, even in close proximity to the disposal pond.

No endangered species were detected on the survey site. Endangered species lists of the U.S. Fish and Wildlife Service and the Texas Organization for Endangered Species were checked, county by county, for Waller County and all surrounding counties. None of the listed species was observed on the Sheridan Site (Appendix 7A, Section 9.0).

Figure 7-1 shows the location and extent of the survey in Waller County.

7.2 Ecological Description - Ecologically, the SDS site and adjacent property lie on the contact line between the Blackland Prairie and the Post Oak Savannah vegetational areas. Examples of both vegetational zones occur in the immediate area, contributing to a high flora and fauna species diversity.

Two other vegetational areas, the Gulf Prairie to the southeast and Pineywoods to the northeast, begin only a few miles away (Figure 7-2). These, too, contribute representative species to the composite community.

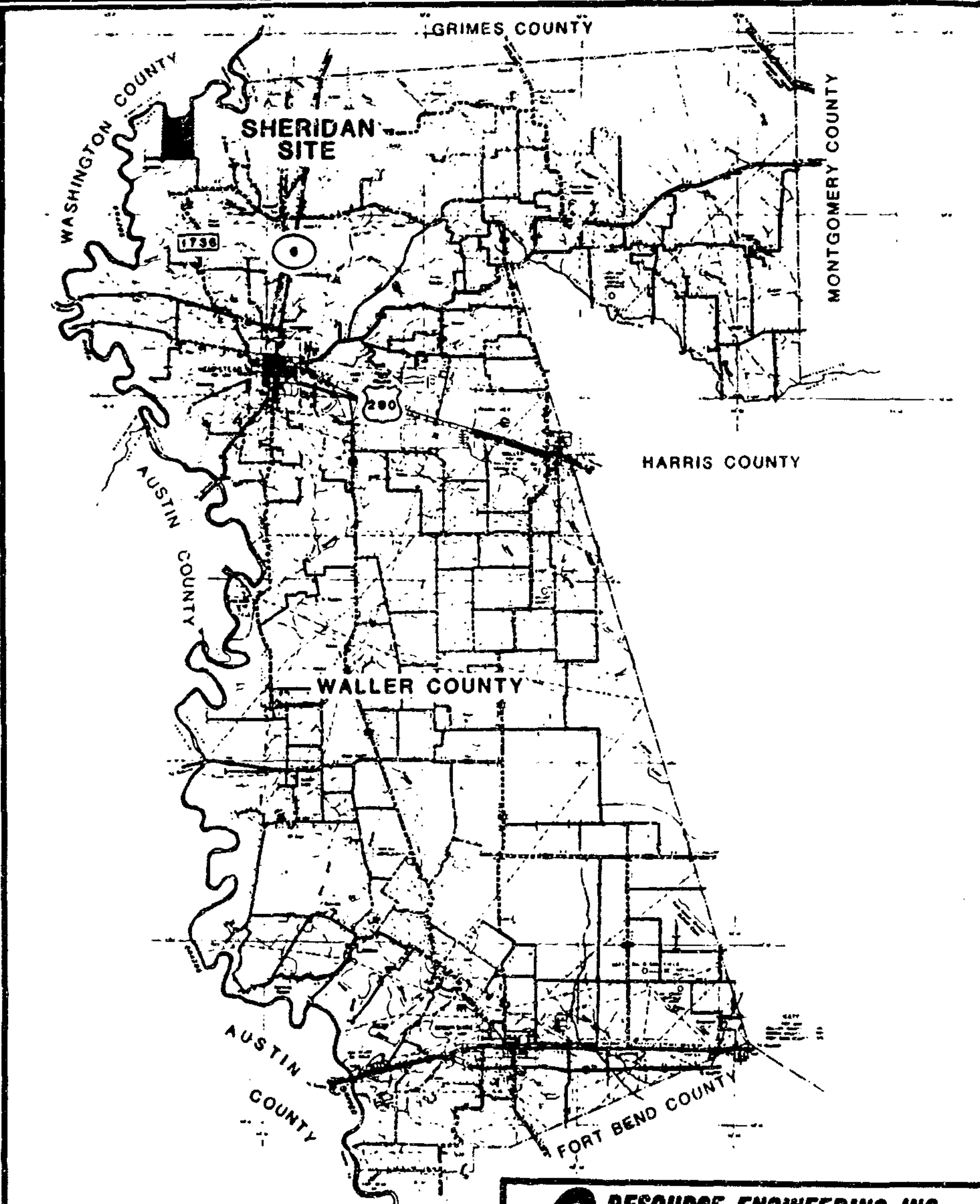

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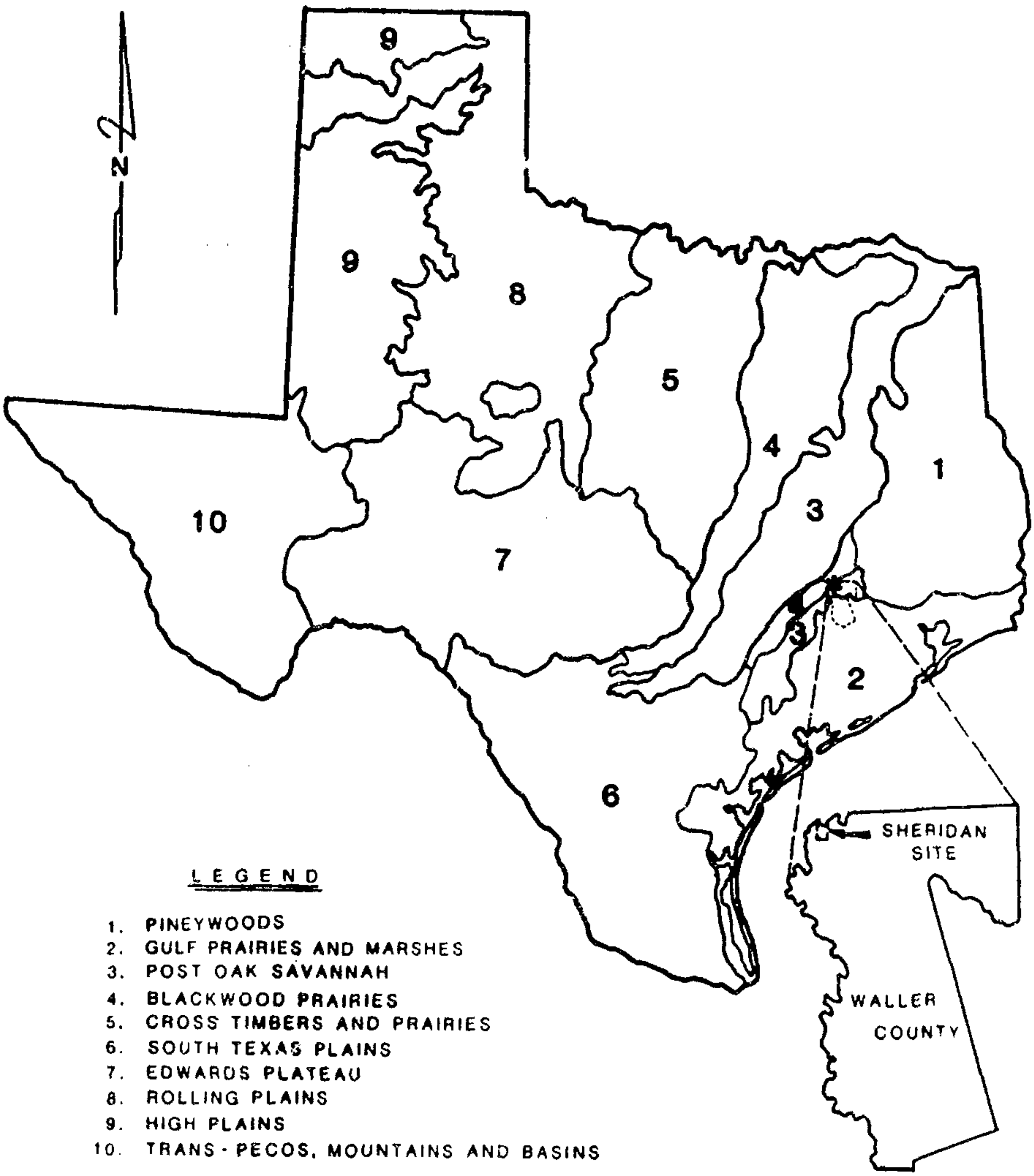
FIGURE 7-1
SHERIDAN SITE
WALLER COUNTY
SHERIDAN DISPOSAL SERVICE

DRAWN BY:	DATE:	PROJECT NO. 288-04



LEGEND

1. PINEYWOODS
2. GULF PRAIRIES AND MARSHES
3. POST OAK SAVANNAH
4. BLACKWOOD PRAIRIES
5. CROSS TIMBERS AND PRAIRIES
6. SOUTH TEXAS PLAINS
7. EDWARDS PLATEAU
8. ROLLING PLAINS
9. HIGH PLAINS
10. TRANS - PECOS, MOUNTAINS AND BASINS

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FIGURE 7-2
ECOLOGICAL AREAS OF TEXAS
SHERIDAN DISPOSAL SERVICE

DRAWN BY: L.C.S.	DATE: 2/18/86	PROJECT NO. 288-04

Soils are predominantly Brazoria clays, with zones of Oklared and Clemville nearer the Brazos River. These soils are generally low in permeability and poorly drained. Refer to Chapter 2 for more information on site soils.

The tract west of the entrance road contains mostly cultivated hay fields and weedy pastures. Small, isolated thickets and wooded tracts provide additional wildlife habitats.

Woodlands cover most of the area east of the survey site. Cedar elm is the major tree species; Hawthorn is the dominant understory shrub. There are also several open pasture, pond, and forest microhabitats as discussed. A general description of the survey area is illustrated in Figure 7-3.

7.3 <u>Wildlife Communities</u> - The survey area is divided into several distinct wildlife communities or biomass. The biomass in the Sheridan property include:

1) the disposal pond;
2) the evaporation system;
3) Clark Lake;
4) the Brazos River bank;
5) the hay fields;
6) pastures;
7) wet thickets; and
8) the river bank woodlands.

The location of these areas is shown in Figure 7-4.

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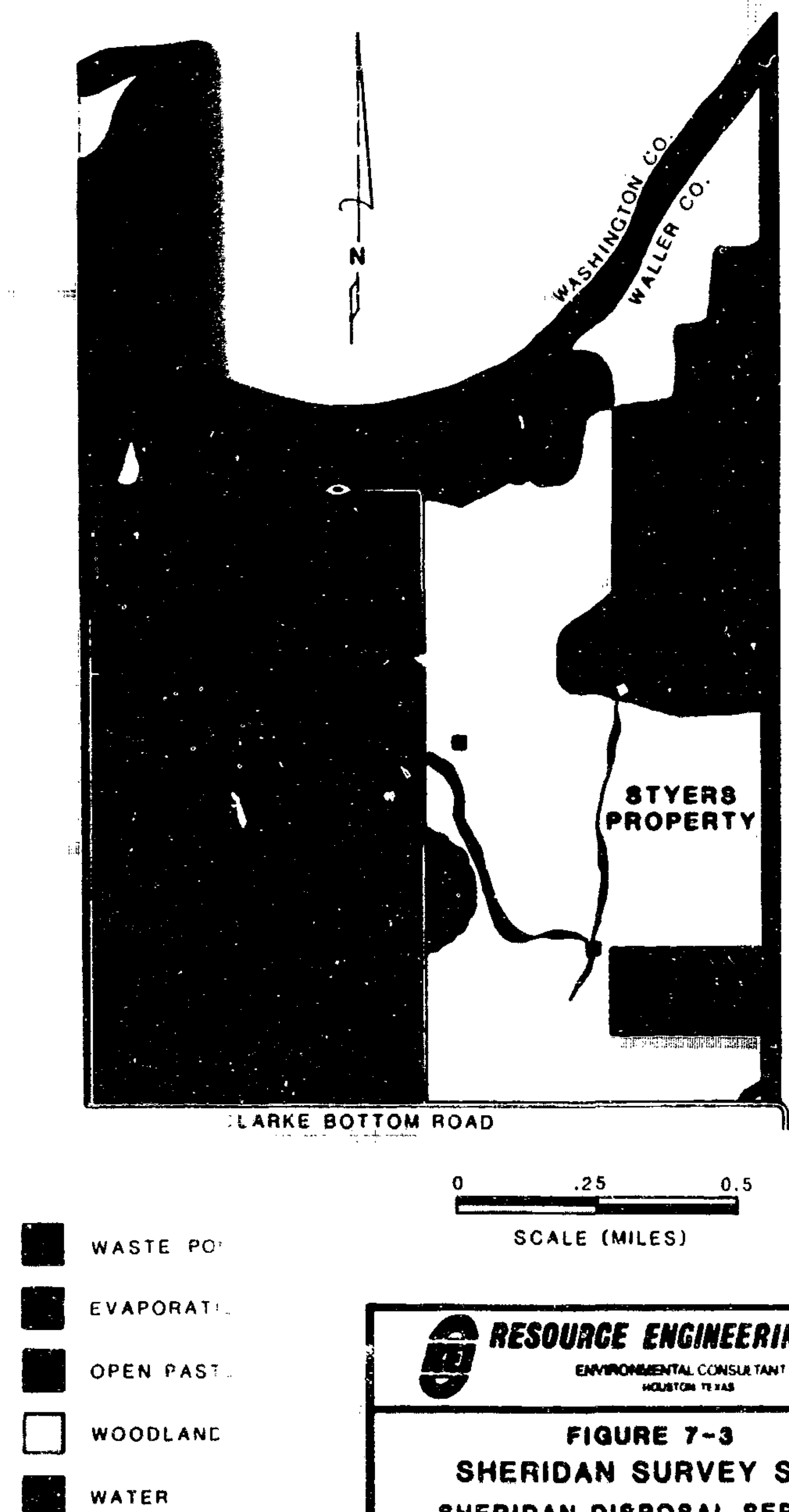

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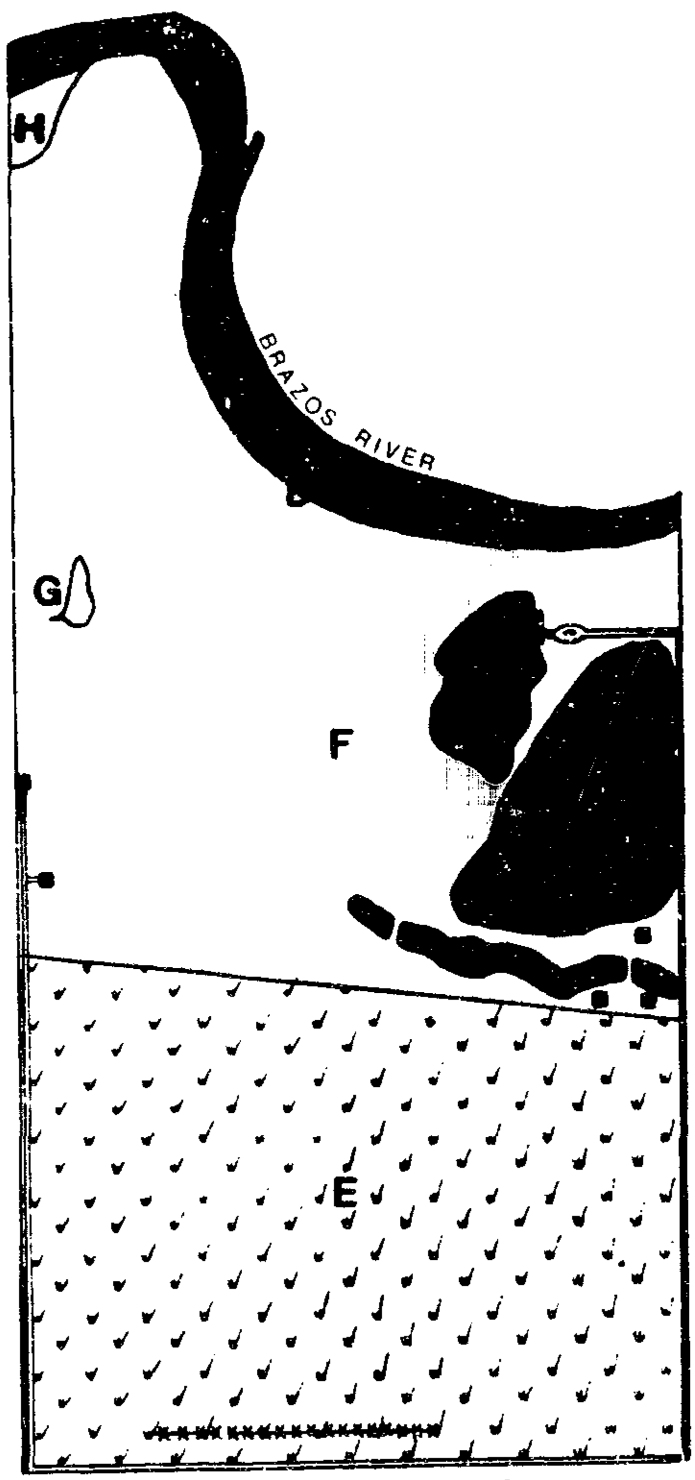
FIGURE 7-3
SHERIDAN SURVEY SITE
SHERIDAN DISPOSAL SERVICE

DRAWN BY	DATE	PROJECT NO
L.M.G.	2-24-86	288-04



A WASTE POND

B EVAPORATION SYSTEM

C CLARK LAKE

D BRAZOS RIVERBANK

E HAY FIELDS

F PASTURE

G WET THICKET

H RIVERBANK WOODLAND

-x-x-x-x-x-x- MAMMAL TRAPS

0 .25 0.5
SCALE (MILES)

003666

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FIGURE 7-4
SHERIDAN PROPERTY
SHERIDAN DISPOSAL SERVICE

DRAWN BY: L.M.G.	DATE: 2-25-86	PROJECT NO. 288-04

7.3.1 Disposal Pond - The earthen dike around the disposal pond is covered with grasses and other herbaceous plants. The slope to the edge of the pond is fairly gentle; the slope to the surrounding field is steeper and eroded by rainfall and cattle paths in several places. Vegetation covers nearly 100% of the dike on the east side of the pond; but emergent plant growth covers only 70-80% of the western side. Bare areas are due primarily to erosion, not to any apparent chemical or physical damage by pond substances. A variety of plants thrives to the water's edge.

Low groundcover consists of bermuda grass (Cynodon dactylon) and a mixture of other grasses. Curly dock (Rumex crispus), rough-seed buttercup (Ranunculus muricatus), white and Caroline clovers (Trifolium repens and T. carolinianum), black medic (Medicago lupulina), Carolina geranium (Geranium carolinianus), wood-sorrel (Oxalis sp.), bull thistle (Cirsium horridulum), clasping henbit (Lamium amplexicaule), southern dewberry (Rubus trivialis), and several other low growing species are mixed with the grasses. Taller giant ragweed (Ambrosia trifida), rattlebush (Sesbania drummondii), silver-leaf nightshade (Solanum elaeagnifolium), tall goldenrod (Solidago altissima), and cocklebur (Xanthium strumarium) are also common.

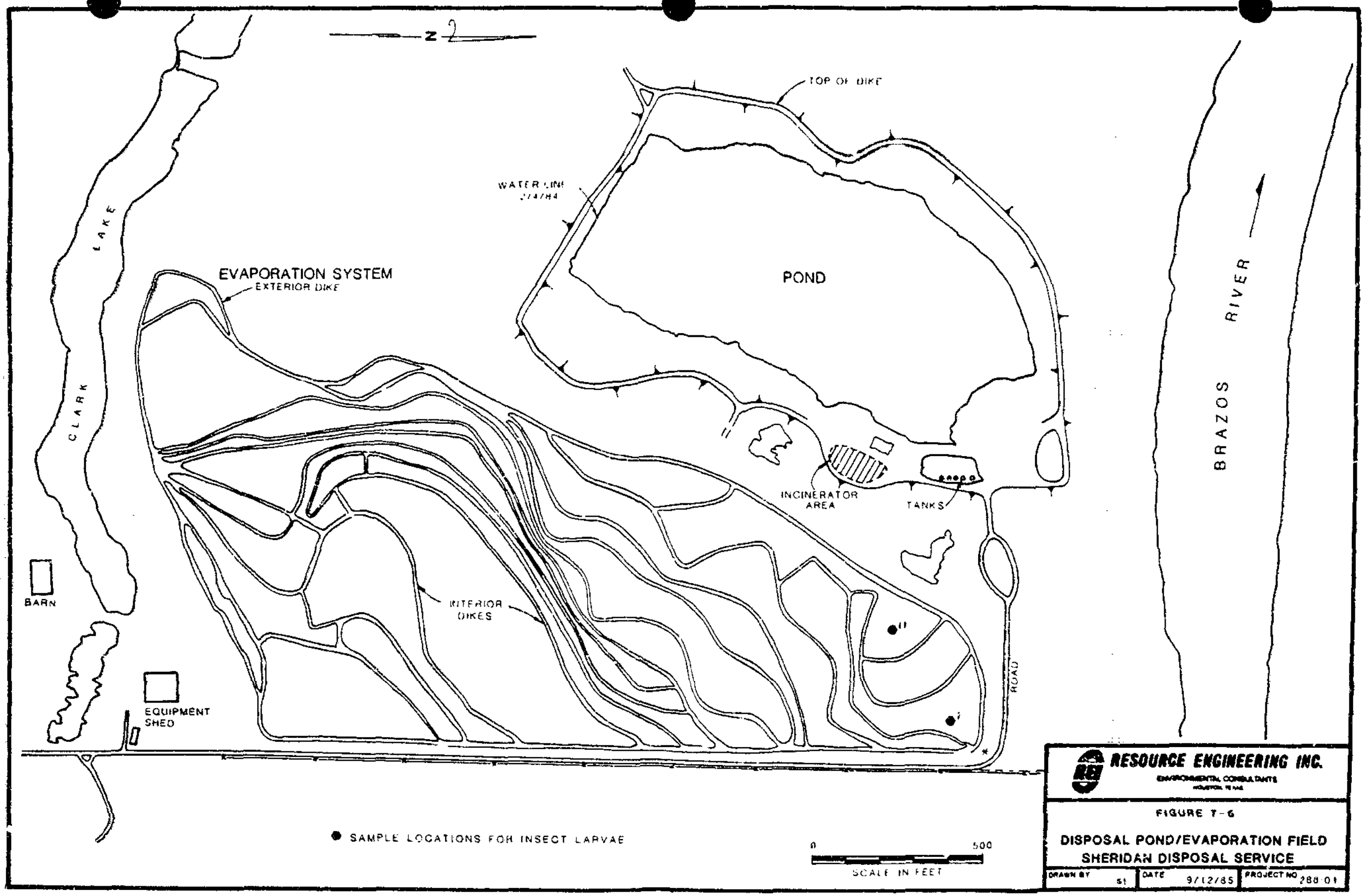
Many of the plant stalks were festooned in winter with egg cases of the black-and-yellow garden spider (Argiope aurantia). Several cases were opened and contained living baby spiders. Their numbers indicated a thriving insect population during warmer seasons; this was confirmed in the June follow-up (Appendix 7B).

Tracks of white-tailed deer (Odocoilus virginianus), raccoon (Procyon lotor), and gray fox (Urocyon cinereoargenteus) were found in hardened mud along the waste lagoon levee. Small pools of water in depressions on the dike harbored thick algal mats and a number of recently metamorphosed bullfrogs (Rana catesbeiana). Bullfrogs and several red-eared turtles (Chrysemys scripta elegans) were also found in a small pond just outside the eastern dike wall.

The wild animals were not sacrificed for biocontamination studies because there was no evidence of stressed populations, even in those species that complete their reproductive cycles within the immediate disposal-pond area. Cattle were the most frequent mammalian visitors, and they were subjected to bioassay (Chapter 8.0). No contaminants above FDA regulatory levels were found.

A recently dead lesser scaup duck (Aythya affinis), the skeletal remains of a red-winged blackbird (Agelaius phoeniceus), and a great blue heron (Ardea herodias) were found along the bank. These birds were covered with oil and presumably died from direct contact with floating oil.

Observation of remains revealed no evidence of scavenging. Scavengers normally dismember a skeleton as they eat flesh. These skeletons were intact. This observation is



N
TOP OF DIKE
WATER LINE
POND
EVAPORATION SYSTEM
EXTERIOR DIKE
CLARK LAKE
BRAZOS RIVER
INCINERATOR AREA
TANKS
INTERIOR DIKES
ROAD
BARN
EQUIPMENT SHED
SAMPLE LOCATIONS FOR INSECT LARVAE
0
500
SCALE IN FEET
RESOURCE ENGINEERING INC.
ENVIRONMENTAL CONSULTANTS
FIGURE 7-6
DISPOSAL POND/EVAPORATION FIELD
SHERIDAN DISPOSAL SERVICE
DRAWN BY
DATE 9/12/85
PROJECT NO 288-01

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consistent with Dr. Tveten's experience that wild animals rarely scavenge on the carcasses of birds that have died after direct contact with oil. Scavengers appear to be repelled by the odor and taste of the oil on the animal.

7.3.2 Evaporation System - Earthen dikes divide the evaporation system into many shallow ponds, similar to a rice field (Figure 7-5). Some sections were flooded a few inches in depth during the survey; others were dry. These would be expected to fill to a greater extent during heavy rains. Various aspects of the evaporation system are shown in Figure 7-6.

Ground cover on the dikes is sparse in winter, and heavier in warmer seasons of the year. It consists primarily of short grasses and clovers. Giant ragweed Slug for (Ambrosia trifida), curly dock (Rumex crispus), cocklebur (Xanthium strumarium), and rattlebush (Sesbania drummondii) grow on the dikes and, to a lesser extent, in the system impoundments themselves.

Tracks of raccoons (Procyon lotor) and an opossum (Didelphis virginiana) were found in the impoundments. A large flock of up to 160 least sandpipers (Calidris minutilla) used the evaporation system as a feeding ground continually during the winter survey; a flock of 130 green-winged teal (Anas crecca) was observed on one occasion. Smaller number of mallard (Anas platyrhynchos), killdeer

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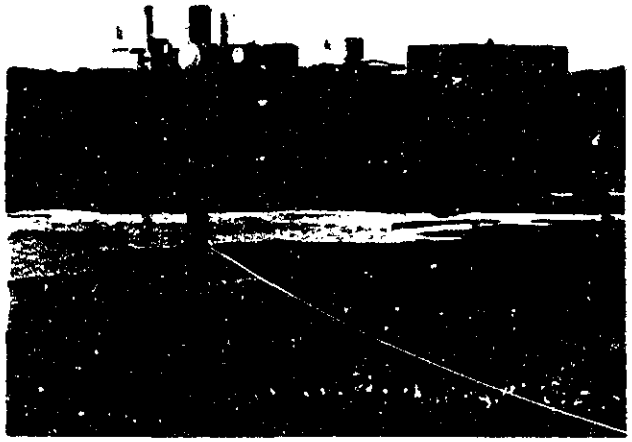
(Charadrius vociferus), blackbellied plovers (Pluvialis squatarols), greater and lesser yellowlegs (Tringa melanoleuca and T. flavipes), common snipe (Gallinago gallinago), water pipits (Anthus spinoletta), red-winged blackbirds (Agelaius phoeniceus) and savannah sparrows (Passerculus sandwichensis) were also seen from time to time, as were a great blue heron (Ardea herodias), and a great egret (Casmerodius albus).

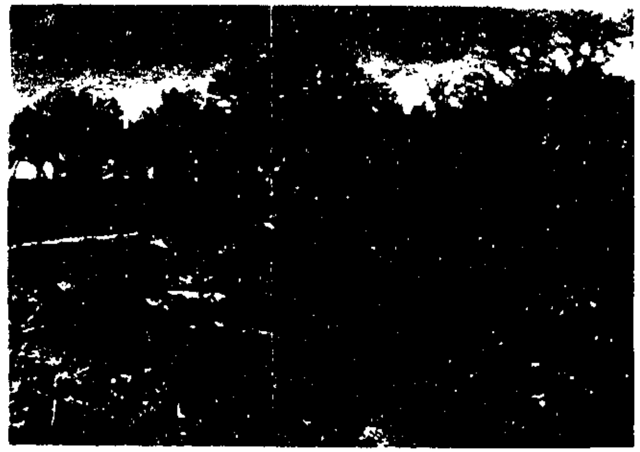
Clearly the construction of this evaporation system has created a new habitat for wildlife on the SDS site; it is one that did not previously exist. Shorebirds and waterfowl flock to the ponds to feed on organisms breeding in the shallow water and wet mud.

To identify the food items of the sandpipers and ducks, mud samples were taken from two locations where the large flocks were observed most often. The samples were washed and screened, and the organisms examined under a microscope. Enormous numbers of two genera of "bloodworms" midge larvae (family Chironomidae), were found as well as several other insect larvae and pupae, all of the order Diptera. Figure 7-7 is an illustration of the insect larvae found.

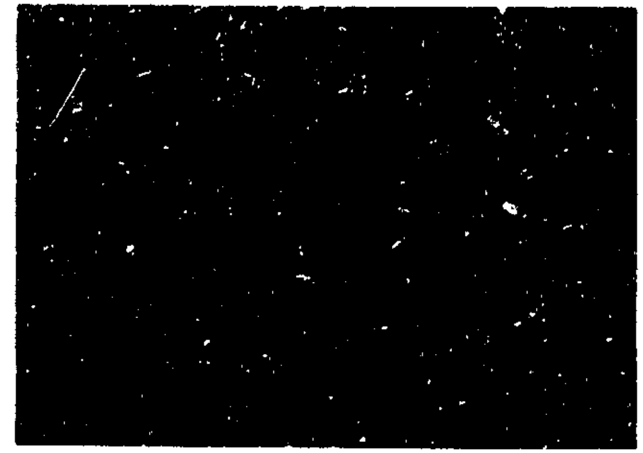
A study of possible chronic effects on birds utilizing the evaporation area as a feeding ground was not deemed feasible, since they were primarily migratory species that move northward to breed. They could possibly be netted and banded, but they would be gone before any cumulative or chronic effects could be assessed.



LEAST SANDPIPERS IN EVAPORATION SYSTEM



EVAPORATION SYSTEM CELL



BIRD TRACKS IN EVAPORATION SYSTEM

CENTRAL SECTION OF CLARK LAKE

RED EARED TURTLE IN CLARK LAKE

BRAZOS RIVER

RESOURCE ENGINEERING INC.
ENVIRONMENTAL CONSULTANTS
HOUSTON, TEXAS

FIGURE 7-6

ILLUSTRATIONS

SHERIDAN DISPOSAL SERVICE

DRAWN BY:	DATE	PROJECT NO.

The fact that these populations are migratory, however, also decreases their exposure to potential hazards and reduces the possibility of chronic toxicity. Birds observed appeared to be outwardly healthy and active.

7.3.3 Clark Lake - Clark Lake is a long, narrow lake formed by damming a natural drainage channel. Clark Lake is divided into 3 sections by two earthen dams; these sections must be considered as biologically separate. A thin screen of large black willows (*Salix nigra*) and locust trees (*Gleditsia* sp.) grows along the edge of Clark Lake, together with the rattlebush (*Sesbania drummondii*). Sugar hackberries (*Celtis laevigata*) and a few pecan trees (*Carya illinoensis*) grow along the higher portions of the banks and are interlaced with the vines of grape (*Vitis* sp.), saw greenbriar (*Smilax bona-nox*), and southern dewberry (*Rubus trivialis*).

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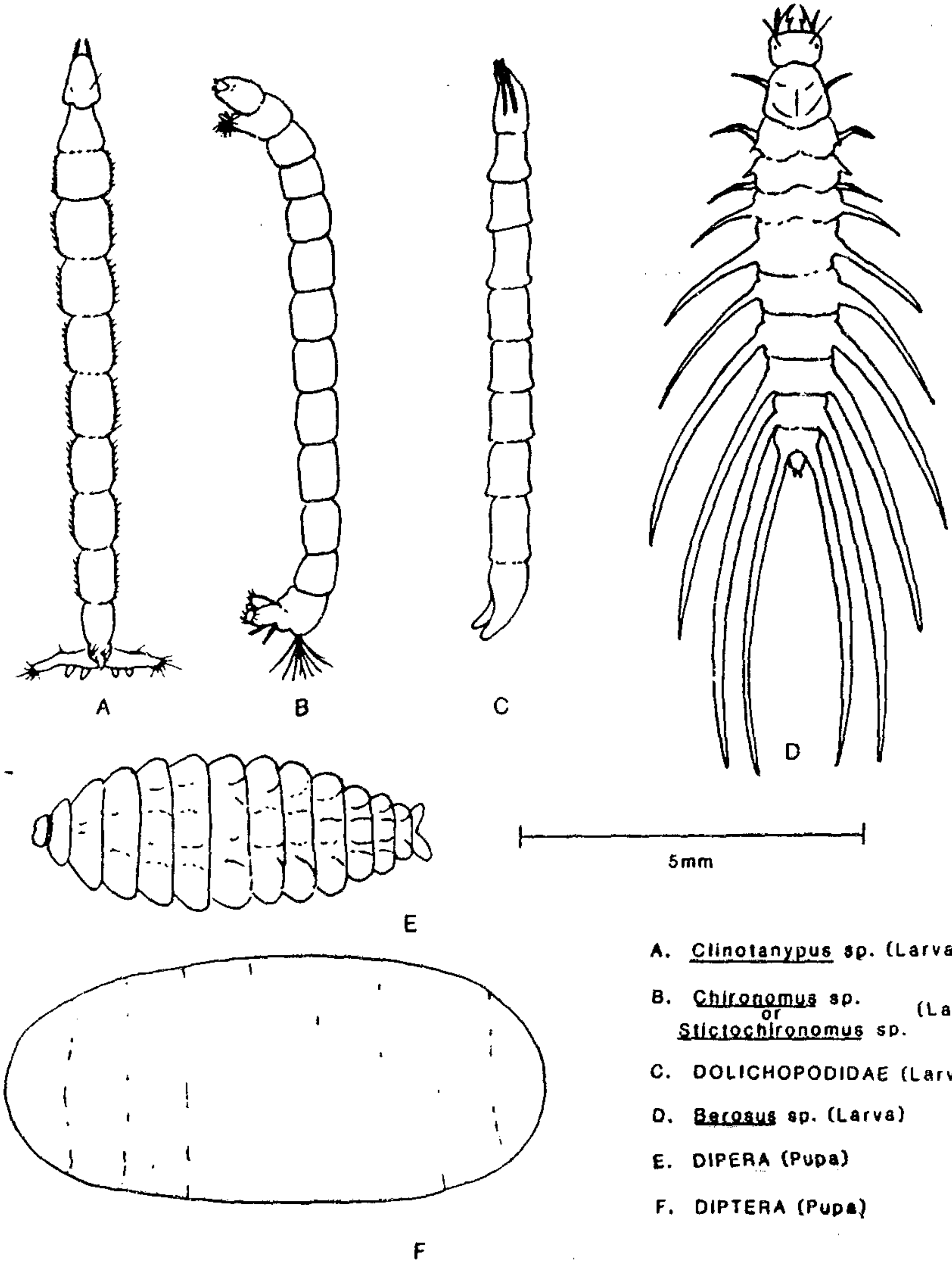
The east section of the lake is filled with floating water-hyacinths (*Eichhornia crassipes*). As many as eight very large red-eared turtles (*Chrysemys scripta elegans*) were seen sunning on floating logs (Figure 7-6); small bullfrogs (*Rana catesbeiana*) and numerous mosquito-fish (*Gambusia* sp.) were observed in the water.

The long, central portion of the lake lacks the water-hyacinths because of the physical barrier of the dam; it is heavily matted instead with pondweed (*Potamogeton nodosus*) (Figure 7-6). Various grasses (family Gramineae) and sedges (family Cyperaceae) grow in shallow water, along with



A. Clinotanypus sp. (Larva)

B. Chironomus sp. or Stictochironomus sp. (Larva)

C. DOLICHOPODIDAE (Larva)

D. Berosus sp. (Larva)

E. DIPERA (Pupa)

F. DIPTERA (Pupa)

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FIGURE 7-7
INSECT LARVAE
FROM EVAPORATION PONDS

DRAWN BY:	DATE:	PROJECT NO.

arrowhead (Sagittaria sp.) and water smartweed (Persicaria hydropiperoides).

The western section is dry during portions of the year; thus it has little of the aquatic life characteristic of the other two.

Belted kingfishers (Ceryle alcyon) were observed feeding on aquatic life on several occasions and a Cooper's hawk (Accipiter coperii) was seen once in the trees. Numerous small birds utilized the habitat from time to time.

During September 1984, Resource Engineering, Inc. conducted an aquatic survey of Clark Lake. This survey was designed to determine the biological diversity in the lake as well as to determine if the aquatic life was undergoing environmental stresses attributable to the SDS waste management area. Sample sites were chosen to account for possible environmental variations which could affect the distribution of organisms.

All locations seined produced comparable numbers of nektonic and amphibius species. Benthic species were found in greater abundance near the shoreline. Aquatic and terrestrial insects were collected from the water's surface. These data are presented in Appendix 7C.

7.3.4 Brazos River Bank - The river bank along the northern edge of the Sheridan survey site is primarily a steep clay bluff descending abruptly to the water (Figure 7-6). Near the eastern boundary, on the adjacent property, a small

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floodplain woodland contains eastern cottonwood (Populus deltoides), pecan (Carya illinoensis), sugar hackberry (Celtis laevigata) and a few green ash (Fraxinus pennsylvanica). Large grape vines (Vitis sp.) drape the branches. A fenceline along the top of the bluff is grown up with hackberry, locust (Gleditsia sp.) and Hercules-club (Zanthoxylum clava-herculis).

The bank becomes more abrupt west of the SDS disposal area, and the trees decrease in size and number. Black willows (Salix nigra) and a few cottonwoods cling to the bank below the brink and extend down to the edge of the water. Few herbaceous plants grow on the steep clay bank except for giant ragweed (Ambrosia trifida) and tall goldenrod (Solidago altissima). Constant erosion from rainfall and river-level fluctuations precludes extensive plant cover or attendant wildlife populations.

7.3.5 Hay Fields - The entire southern portion of the Sheridan property, from the entrance road on the eastern boundary to the oilfield road and western fenceline, has been planted in hay. During the past season, this was a tall commercial sorghum known as "Hay Grazer." The last cutting was not completed in the fall, and the hay remained in the field. A portion of this was being plowed during the winter study period.

The only ecological diversity within this section is along the southern and western fencerows and in small, wet drainages. The southern fenceline contains sugar

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hackberry (Celtis laevigata) and a few Hercules-club (Zanthoxylum clava-herculis) overgrown with dewberry and blackberry (Rubus sp). Low drainage areas contain various grasses (Gramineae), sedges (Cyperaceae), false dragon-head (Physostegia sp.) and horsemint (Monarda sp.).

A wide ditch between the oilfield road and the fenceline on the western boundary is relatively bare except for stalks of giant ragweed (Ambrosia trifida).

Birds seen using these fields included large numbers of eastern meadowlarks (Sturnella magna) and savannah sparrows (Passerculus sandwichensis). Hawks, vultures and crows were seen frequently, and flocks of geese passed overhead several times. It appeared that one flock of snow geese (Chen caerulescens) intended to land in the hayfield but was frightened by a tractor and continued on.

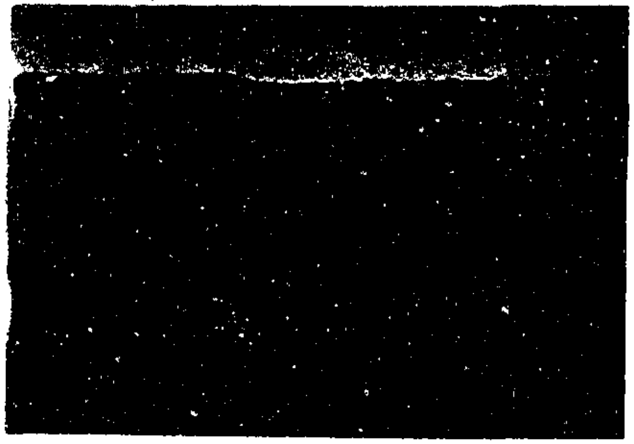
Seventy Sherman rodent traps were set along the southern fenceline (Figure 7-4) at 30-foot intervals and baited with a mixture of millet and sunflower seeds. Set before dusk and picked up the following morning, they produced: a northern pygmy mouse (Baiomys taylori), a fulvous harvest mouse (Reithrodontomys fulvescens), and a hispid cotton rat (Sigmodon hispidus); this was a normal sample for a cultivated area.

7.3.6 Pasture - The northern portion of the Sheridan property consists of open pasture. Short grasses, including Bermuda grass (Cynodon dactylon), dominate in the east (Figure

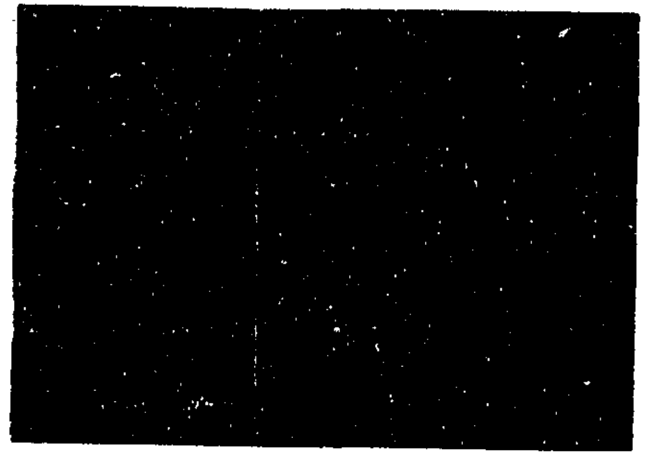
7-8); the western portions are much more weedy. No differences in type or abundance of vegetation were seen in the immediate vicinity of the disposal pit or northwestward from the pit to the river bank, the direction of flow of the shallow groundwater.

Taller growth includes the dominant giant ragweed (Ambrosia trifida) and silver-leaf nightshade (Solanum elaeagnifolium), as well as scattered cocklebur (Xanthium strumarium), goldenrod (Solidago sp.), and croton (Croton sp,). At the northwest corner of the tract, the dense weeds (chiefly ragweed) reach a height of 6 to 8 feet. 003678

Most abundant of the other herbaceous plants are: blue-eyed-grass (Sisyrinchium sp.), curly dock (Rumex crispus), peppergrass (Lepidium virginicum), black medick and and spotted bur-clover (Medicago lupulina and M. arabica), white and Carolina clover (Trifolium repens and T. carolinianum), Carolina geranium (Geranium carolinianum), axocatzin (Sida rhombifolia), pink evening-primrose (Oenothera speciosa), chervil (Chaerophyllum tainturieri) ponyfoot (Dichondra carolinensis), tuber vervain (Verbena rigida), frog-fruit (Phyla sp.), clasping henbit (Lamium amplexicaule), groundcherry (Physalis sp.), fleabane (Erigeron sp.), ragwort (Senecio sp.), bull thistle (Cirsium horridulum), Indian blanket (Gaillardia pulchella), and several other unidentified composites.

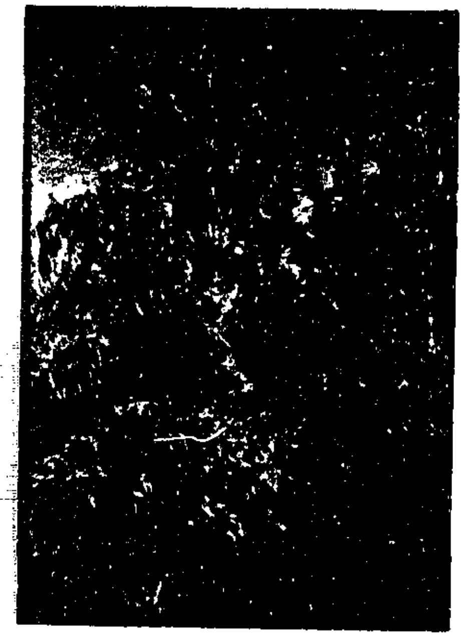


PASTURE

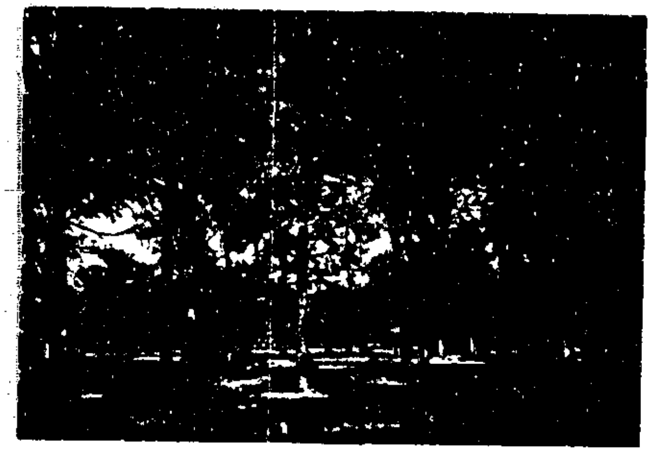


WET THICKET

RIVERBANK WOODLANDS



ADJACENT WOODS
LICHENS ON TREES



CEDAR ELM WOODLANDS

PECAN OAK WOODLANDS

RESOURCE ENGINEERING INC.

FIGURE 7-6
ILLUSTRATIONS
SHERIDAN DISPOSAL SERVICE

DRAWN BY:	DATE	PROJECT NO.

Several areas contained fresh series of pocket gopher mounds. Presumably these were of the Louisiana pocket gopher (Geomys breviceps), although they could possibly have been Geomys attwateri. The Brazos River is generally regarded as the boundary between these newly separated and very similar species. No attempt was made to trap the gophers.

The dominant birds were essentially the same as in the cultivated fields and included loose flocks of eastern meadowlarks (Sturnella magna) and wintering savannah sparrows (Passerculus sanwichensis). Of special note, however, was a flock of 50 McCown's longspurs (Calcarius mccownii), a very unusal winter sighting in this area (Feltner and Pettingill, 1980). Local birders have reported them at other locations in Waller County this year.

Fire-ant mounds are abundant throughout the pasture, as they are in virtually every other habitat. Crayfish towers were also found in several places.

7.3.7 Wet Thicket - Isolated in the Sheridan pasture is a wet thicket of trees and shrubs (Figure 7-8). Approximately 150 feet across, it is the lowest spot in that portion of the survey area. At the time of the study, the water was 4 to 6 inches deep beneath the trees.

Vegetation consists of large black willows (Salix nigra) and water locusts (Gleditsia aquatica) with smaller green ash (Fraxinus pennsylvanica), hackberry (Celtis laevigata), and buttonbush (Cephalanthus occidentalis). Sedges

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(Cyperaceae) and dense tangles of dewberry (Rubus sp.) fringe the wet area of the thicket.

Yellow-rumped warblers (Dendroic coronata) were the only birds found in the thicket, but tracks of herons and several smaller birds in the mud indicate they are frequently present. No mammal tracks were found, nor were any frogs or other reptiles or amphibians detected in the water here. Because of its small size, the tract appears to serve mainly as a temporary shelter for transient animals (Appendix 7A, 7.1.7).

7.3.8 Riverbank Woodland - At the far northwest corner of the Sheridan tract is a floodplain woodland that extends along the bank of the Brazos River onto adjacent property to the west. About 6 to 8 feet lower than the surrounding area, with a more alluvial soil, it provides a unique ecological niche (Figure 7-8).

On the slope around the edge are sugar hackberry (Celtis laevigata) and pecan trees (Carya illinoensis), draped heavily with large vines of grape (Vitis sp.,) and poison-ivy (Rhus toxicodendron). The bottom is relatively open and contains quite large eastern cottonwoods (Populus deltoides) and sycamores (Platanus occidentalis).

Several armadillo burrows (Dasypus novemcinctus) and an active den of a gray fox (Urocyon cinereoargenteus) were discovered. Bird species included eastern bluebird (Sialia sialis), white-throated sparrow

003681

(Zonotrichia albicollis), field sparrow (Spizella pusilla), and vesper sparrow (Pooecetes gramineus).

7.4 Adjacent Property - The adjacent Styers property is heavily wooded; smaller, cleared pasture areas are scattered throughout. The area surveyed extends from the site entrance on the west to the eastern edge of the woods. The latter boundary corresponds roughly to the corner where Clarke Bottom Road turns south. Two north-south fences divide the tract roughly into thirds and serve as boundaries for small pastures or thickets that reflect varying land-use histories. Figure 7-9 shows the various environs found in the adjacent property.

Cedar elm dominates the woodland with an understory of hawthorn covered with greenbriar vines. Tree limbs are heavily draped with an epiphytic covering of various fruticose and foliose lichens, most dramatic of which is old man's beard (Usnea sp.). Spanish-moss (Tillandsia usneoides) also grows on some of the larger trees (Figure 7-8), as does the semiparasitic mistletoe (Phoradendron tometosum). The latter is particularly prevalent on the southern edge of the tract along Clarke Bottom Road.

Groundcover in the woodland consists of a mixture of grasses and herbaceous plants that are heavily grazed by cattle. Blue violet (Viola sp.), Carolina buttercup (Ranunculus carolinianus), early buttercup (R. fascicularis)

003682

and rough-seed buttercup (R. muricatus) are prominent in moister, shady areas. Open, sunny spots contain lyre-leaf sage (Salvia lyrata) and self-heal (Prunella vulgaris).

Most abundant of the small woodland birds in winter were the American goldfinches (Carduelis tristis). An estimated 1,500 were seen one day, most of them in one enormous flock. The seeds of cedar elm are favored food items of the goldfinch, and the preponderance of that tree species apparently ensures a correspondingly high finch population. Small feeding flocks of kinglets, warblers, woodpeckers, chickadees and titmice were also frequently encountered. The high density of seed-eating birds argues for highly reproductive success and good vitality of the large cedar elms (Appendix 7A, Section 7.2.1).

A pair of red-shouldered hawks (Buteo lineatus) and a pair of barred owls (Strix varia) were seen on several occations and were frequently heard calling. These raptors are undoubtedly permanent nesting residents and indicate a stable forest environment. The large pileated woodpecker (Dryocopus pileatus) was also observed.

The northwest corner of the adjacent woodland is unique in the survey area in that it contains a mixture of very large pecan (Carye illinoensis) and southern red oaks (Quercus falcata) (Figure 7-8). Both species appear to be in good health and are producing large quantities of nuts and acorns.

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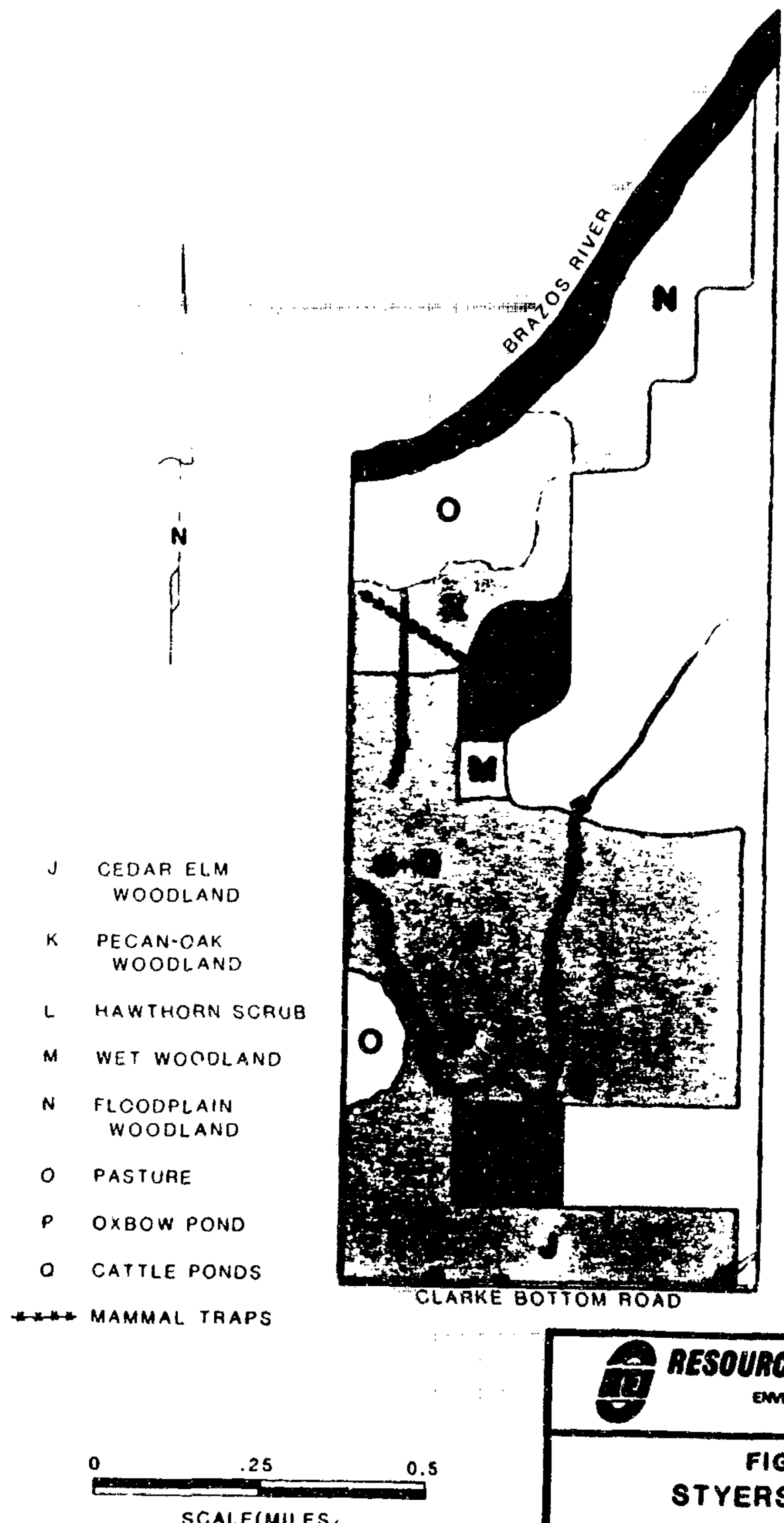

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ENVIRONMENTAL CONSULTANTS
HOUSTON TEXAS

FIGURE 7-9
STYERS PROPERTY
SHERIDAN DISPOSAL SERVICE

DRAWN BY	DATE	
L.M.G.	2-24-86	288-04

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American and cedar elms (Ulmus americana and U. crassifolia), hawthorn (Crataegus sp.) and yaupon holly (Ilex vomitoria) are also present in this area and make this a denser woods than that which occurs across the rest of the tract. Stem densities here average 30 trees of more than 2-inch diameter per 400 square feet.

Vines that envelop the trees and further add to the forest density include grape (Vitis sp.), Carolina snailseed (Cocculus carolinus), southern dewberry (Rubus trivialis), poison-ivy (Rhus toxicodendron), rattan-vine (Verchemia scandens), and saw greenbriar (Silax bona-nox). The resulting thickets provide additional shelter and food for flocks of foraging birds. An eastern cottontail (Sylvilagus floridanus) was observed here, as was a fox squirrel (Sciurus niger).

A trapline of 90 small Sherman livetraps was placed at 30-yard intervals in a winding course through this section (Figure 7-7). However, no rodents were captured overnight. This can be explained by a lack of suitable ground cover due to heavy grazing, even in moderately dense segments of the woods. There is very little good habitat for mice; the surrounding woodland is even more open. Plentiful natural food from fruiting plants would also decrease trapping success (Appendix 7A, Section 7.2.2).

Two sections of the woods, adjacent to open pastures have been cleared of all large trees sometime in the past and now contain primary hawthorn (Crataegus sp.) with tangled thickets of saw greenbriar (Smilax bona-nox) (Figure 7-10).

Birds frequenting these shrubby thickets included: mourning dove (Zenaida macroura), eastern phoebe (Sayornis phoebe), house wren (Troglodytes aedon), northern mockingbird (Mimus polyglottos), brown thrasher (Toxostoma rufum), northern cardinal (Cardinalis cardinalis), song sparrow (Melospiza melodia), Lincoln's sparrow (M. lincolnii), white-throated sparrow (Zonotrichia albicollis), white-crowned sparrow (Z. leucophrys), Harris' sparrow (Z. querula) and dark-eyed junco (Junco hyemalis).

These microhabitats, however, are too small to serve as unique niches for resident wildlife; most of the birds observed were adventitious feeders.

A small segment of the adjacent woodland is lower and wetter and represents a very different microhabitat. Numerous green ash trees (Fraxinus pennsylvanica) are scattered among the larger cedar elms (Ulmus crassifolia), and the spongy ground is covered with a sphagnum-type moss of undetermined species. Principal herbaceous plants visible during the study were blue violet (Viola sp.), rough-seed buttercup (Ranunculus muricatus) and a bedstraw (Galium sp.). The area is probably too small, however, to attract unique wildlife species.

CATTLE POND IN ADJACENT WOODLAND

OXBOW LAKE

RESOURCE ENGINEERING INC.
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HOUSTON TEXAS

FIGURE 7-10
ADJACENT WOODLANDS
SHERIDAN DISPOSAL SERVICE

DRAWN BY	DATE	PROJECT NO. 288-04

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The northeast corner of the adjacent woodland, bordering the Brazos River, is several feet lower than most of the surrounding land and contains very different floral components. Large sugar hackberry trees (Celtis laevigata) combine with pecan (Carya illinoensis), southern red oak Quercus falcata), white oak (Quercus alba), and post oak (Quercus stellata). There are very few understory shrubs, and the ground was heavily grazed and trampled by cattle at the time of the survey.

Fallen timber is much more abundant in this habitat; a number of invertebrate species were located by turning over logs. The same procedure of rolling logs also revealed several ground skinks (Leiolopisma laterale). No other reptiles were observed. In the experience of the site investigator, this paucity of reptile forms, as with the scarcity of small rodents, should be attributed to lack of adequate ground cover. Except for the fallen logs, the ground in this woodland section was essentially bare mud, pock-marked with cattle tracks.

Several armadillo (Dasypus novemcinctus) burrows were found, and a flock of as many as 150 common grackles (Quiscalus quiscula) foraged through the open woods.

Several small areas throughout the adjacent property have been cleared of all trees and shrubs and are heavily grazed by cattle. Groundcover consists of a mixture of short grasses and many of the herbaceous plants found in the adjacent

Sheridan pasture. Isolated patches of taller weeds include giant ragweed (Ambrosia trifida), goldenrod (Silidago sp.), milkweed (Asclepias sp.), and silver-leaf nightshade (Solanum elaeagnifolium).

A very distinctive feature of the adjacent woodland is a long, narrow pond that begins at the entrance road across from Clark Lake and runs generally eastward across the tract. It is apparently an old oxbow of the Brazos River and provides a unique habitat for both plants and animals (Figure 7-10).

Growing in and along the water's edge are green ash (Fraxinus pennsylvanica), water locust (Gleditsia aquatica), western soapberry (Sapindus drumondii) and rattlebush (Sesbanis drumondii). The western end of the pond, adjacent to Clark Lake, is filled with water-hyacinth (Eichhornia crassipes); the remainder has a heavy growth of various sedges (Cyperaceae), arrowhead (Sagittaria sp.), and floating water smartweed (Persicaria hydropiperoides).

Numerous mosquito-fish (Gambusia sp.), red-eared turtles (Chrysemys scripta elegans), small bullfrogs (Rana catesbeiana), fishing spiders (Dolomedes sp.), and unidentified water insects indicate a fairly reliable water supply.

Two pairs of wood ducks (Aix sponsa) and several mallards (Anas platyrhynchos) were flushed from the pond on several occasions. Yellow-rumped warblers (Dendroica coronata) routinely fed through the overhanging branches.

Three fairly large, square, manmade ponds are scattered through the adjacent tract. These "tanks" have heavy algal growths and contain mosquito-fish (<u>Gambusia</u> sp.) and aquatic insects. They are visited by a variety of birds and mammals, including ducks, herons, raccoons and deer.

7.5 <u>Birds</u> - A composite list of 73 bird species was accumulated during five winter visits to the SDS site. Nine more were added in June, 1986. These are summarized in Table 2 in Appendices 7A and 7B. The common and scientific names and phylogenetic order follow the new American Ornithologist's Union (A.O.U.) <u>Check-List of North American Birds</u>, 6th Ed., 1983, as reviewed by Bryan et al (1984). Taxonomy and names differ significantly from older guidebooks that are still frequently used.

The species list, of course, is highly dependent on the season of the year. Many birds present in January move farther north to nest. Their places are taken, in turn, by others that arrive after wintering in Central or South America. Confirmed nesting species are indicated in Appendix 7B, Table 2. Species diversity reaches its maximum during spring and fall migrations when numerous warblers, vireos, thrushes, orioles, grosbeaks, tanagers and buntings move across or up the Texas Coast. A number of these migrants might be expected to visit the area. A species list was compiled by birdwatching intensively, using 10 X 40 Zeiss binoculars.

The site investigator, Dr. Tveten, an experienced Texas birder and coauthor of A Birder's Guide to the Texas Coast (James A. Lane and John L. Tveten), considers the 82 species seen to be an excellent total for so small an area. Most of the expected species were encountered, sometimes in unexpectedly high numbers. American goldfinches (*Carduelis tristis*), for example, were present in a flock of approximately 1,500 individuals, probably because of the abundance of cedar elms, the seeds of which are a favorite goldfinch food.

Bird populations on the site appear to be diverse, numerous, and outwardly healthy. The greatest immediate threat is in physical contact with floating oils and chemicals in the disposal pond. No endangered bird species were seen on the SDS site.

7.6 Mammals - Evidence was found on the site of 12 different mammal species. Four were actually observed in the woodland: Virginia opossum, nine-banded armadillo, eastern cottontail, and fox squirrel. Three rodents were live-trapped: fulvous harvest mouse, northern pygmy mouse, and hispid cotton rat. Three were identified from tracks (Murie, 1974): gray fox, raccoon, and white-tailed deer. An active den of the gray fox was also found, although the animal was not observed. The diversity of mammal species found at the site was high as indicated by area checklists and the investigator's prior experience. Most potential residents were detected.

7.7 Endangered Species - The only endangered species federally listed for Waller or adjacent Washington County (U.S. Fish & Wildlife Service communication) is the bald eagle (Haliaeetus Leucocephalus). No eagles were seen on the SDS site, and no evidence of nesting was detected. There are no known bald eagle nests in that vicinity.

Other endangered species listed for adjacent Harris and Grimes counties include the arctic peregrine falcon (Falco peregrinus tundrius), brown pelican (Pelecanus occidentalis) and Navasota ladies'-tresses (Spiranthese parksii), a small wild orchid. Texas bitterweed (Hymenoxys texana) has been proposed for listing.

It is remotely possible that a peregrine falcon could move through the SDS site, but it is no more likely to follow such a route than any other. The brown pelican, listed for Harris County, is a salt-water species that needs no consideration as a potential visitor.

The Spiranthes is known from Grimes County, but has not been found in Waller County. The habitat does not seem appropriate, and its presence is very unlikely. None was detected during the survey. Hymenoxys texana is now known only from three small populations near Houston in Harris County.

Consideration was also given to the potential for the Houston toad (Bufo houstonensis). The species has not been reported in Waller County, however, and the habitat does not

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appear appropriate. The toad requires a more sandy soil than exists on the SDS site.

The most recent list of the Texas Organization for Endangered Species (T.O.E.S.), Endangered, Threatened, & Watch List of Plants of Texas, (December 1983), was also examined for species that are state-listed but not on the federal roll. None is known to occur in Waller County.

7.8 Bioaccumulation - Fat tissue and blood samples were taken from Mr. Sheridan's cattle (8.2.3) to assess the potential for bioaccumulation of heavy metals and organic compounds. Cattle were chosen as the subjects because, prior to erecting the fence to limit site access, they had free range of the entire site. They were frequently observed drinking water from the evaporative system and consuming vegetation in the evaporative system and on the Pond Levee.

At the time of the sampling, cattle were the most commonly found mammal at the site. Considering the migratory nature of most of the other animals observed at the site, the cattle as a stable population were a good indicator of potential bioaccumulation.

Polychlorinated biphenyls (PCBs) were selected because of the organic compounds found at the site; they had the highest Biological Concentration Factor (BCF) (Table 3-24) and, if present, would readily accumulate in animal fat. Cattle blood samples were taken because lead accumulates in blood after ingestion of contaminated soils or plants.

Test results revealed (Table 8-1) no detectable levels of PCB in animal fat tissue and no lead in their blood.

7.9 Conclusions - The ecological survey may be summarized with the following conclusions.

- No stress on the surrounding plant and animal communities was attributable to the materials in the diked disposal pond. An abundance of floral and faunal species occurs on the dike, even to the edge of the water. No differences in plant growth were found in the direction of the flow of shallow ground water toward the Brazos River nor in any other direction. There is no runoff toward Clark Lake from the disposal pond (Figure 7-5).

- Diversity of ecological habitats at the site is high, with an attendant diversity and abundance of plant species. Diversity of animal species is correspondingly high with total numbers as large or larger than would be expected.

- Birds are particularly abundant, both with regard to species and to individual numbers.

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- Construction of a diked evaporation field created a new habitat for wildlife on the SDS site--one that did not previously exist. Shore birds and water fowl flock to the ponds to feed on organisms breeding in the shallow water and wet mud. See Appendix 7A, 7.1.2.

- Clark Lake on the Sheridan tract and an oxbow pond on the adjacent Styers property appear to have thriving populations of aquatic plants and animals. Fish, turtles, frogs, and insects were seen in abundance. A number of birds and mammals feed on these organisms.

- Forest trees adjacent to the disposal pit and evaporation field appear to be in good health. Nearby pecans and southern red oaks are very large and are producing good crops of nuts and acorns. Large cedar elms are extremely productive.

- No deleterious effects on wildlife can be attributed to oils or chemicals spreading from the disposal area. A seeming scarcity of small rodents and terrestrial reptiles almost certainly stems from a lack of suitable ground cover due to heavy grazing of cattle.

- The only immediate threat to animal life from the disposal pond is one of physical contact by water fowl. Birds landing on the pond may be injured or killed by contact with floating oil.

- No federal or state-listed endangered plant or animal species were detected on the site. One bird, the bald eagle, could conceivably wander through in winter, but no evidence of nesting was found.

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8.0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

There appears to be no damage attributable to the SDS site to: flora or fauna living on or around the area; the Brazos River and any users; users of the shallow aquifer; and users of adjacent property.

Air monitoring both around the waste pond and at the perimeter of the site showed no concentrations above background of RCRA organic compounds on the Hazardous Substances List.

Cattle grazing in the area were sampled for lead and PCB levels in blood and fat tissue. No levels of either constituent were found above detectable levels.

An acute oral toxicity test was performed on rats using pond sludge. No rats died using a dosage level of 5050 mg/kg. According to Casarette and Doull's Toxicology: The Basic Science of Poisons, a material with an LD_{50} between 5,000 mg/kg and 15,000 mg/kg is considered slightly toxic. Long-term, chronic effects and carcinogenic effects will be further evaluated in the Site Endangerment Assessment.

The acute oral test protocol is required by EPA in evaluation of hazardous substance to human and domestic animals (EPA publication 540/9-82-025, November 1982). The complete toxicological report is found in Appendix 8A of the RI.

The acute oral toxicity test was run to determine an LD_{50} for the lagoon sludge. Although the lagoon sludge has many individual components, these components, collectively, may produce toxic effects different from the individual components.

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As an acute poison, benzene produces narcotic effects. High chronic doses of benzene have been associated with leukemia, aplastic anemia and other blood disorders. This, however, does not mean that some mixture in which benzene is found would produce the same acute or chronic effects. Risk calculations and further discussion of this phenomena will need to be addressed in an endangerment assessment.

8.1 Potential Receptors - The potential exposure routes include: direct contact with the waste pond and evaporation system, surface water, groundwater, soil and air. These exposure routes were evaluated with respect to the following:

1) all flora and fauna living on or adjacent to the site, either north or south of the Brazos River;
2) the Brazos River and any users;
3) users of adjacent property;
4) any users of the shallow groundwater; and
5) the occasional visitor or trespasser on site.

Those receptors with potential for direct contact are vegetation and animal life, both wild and domestic, that presently reside at the site and human visitors or trespassers. To prevent trespassing or accidental exposure, a fence has been installed surrounding the site.

8.1.1 Human Receptors - A regional map of communities within a 12-mile radius of the site is presented in Figure 8-1.

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The 1985 estimated population for this 12-mile radius area is 15,527, which amounts to an average of 35 people or 12 households per square mile. This is an increase of 23 percent from the 1980 census. An estimated increase in population of only 14 percent is expected by the year 1990. The average household size, 3 people, has remained constant and is not expected to change through 1990.

Over 60% of the surrounding population resides in the communities of: Hempstead, Prairie View, Chappel Hill and Washington. These communities are all in excess of 8 miles from the site. Prairie View is primarily a college community and, as such, its population will be in continuous change. Other communities near the SDS site are relatively stable, and all indications are they will remain that way.

8.1.2 Flora and Fauna - The diversity of ecological habitats at the SDS site supports a wide variety of plant, animal, and bird species. Numerous shore birds and water fowl were observed on the evaporation system. Clark Lake and the Oxbow Pond on the adjacent property to the east appear to have thriving populations of fish, turtles, frogs, insects and aquatic plants.

8.2 Public Health Concerns - To assess the potential risk to the public health, it is necessary to estimate possible routes of exposure. Three potential exposure pathways have been investigated for pollutants at the SDS site. These are:

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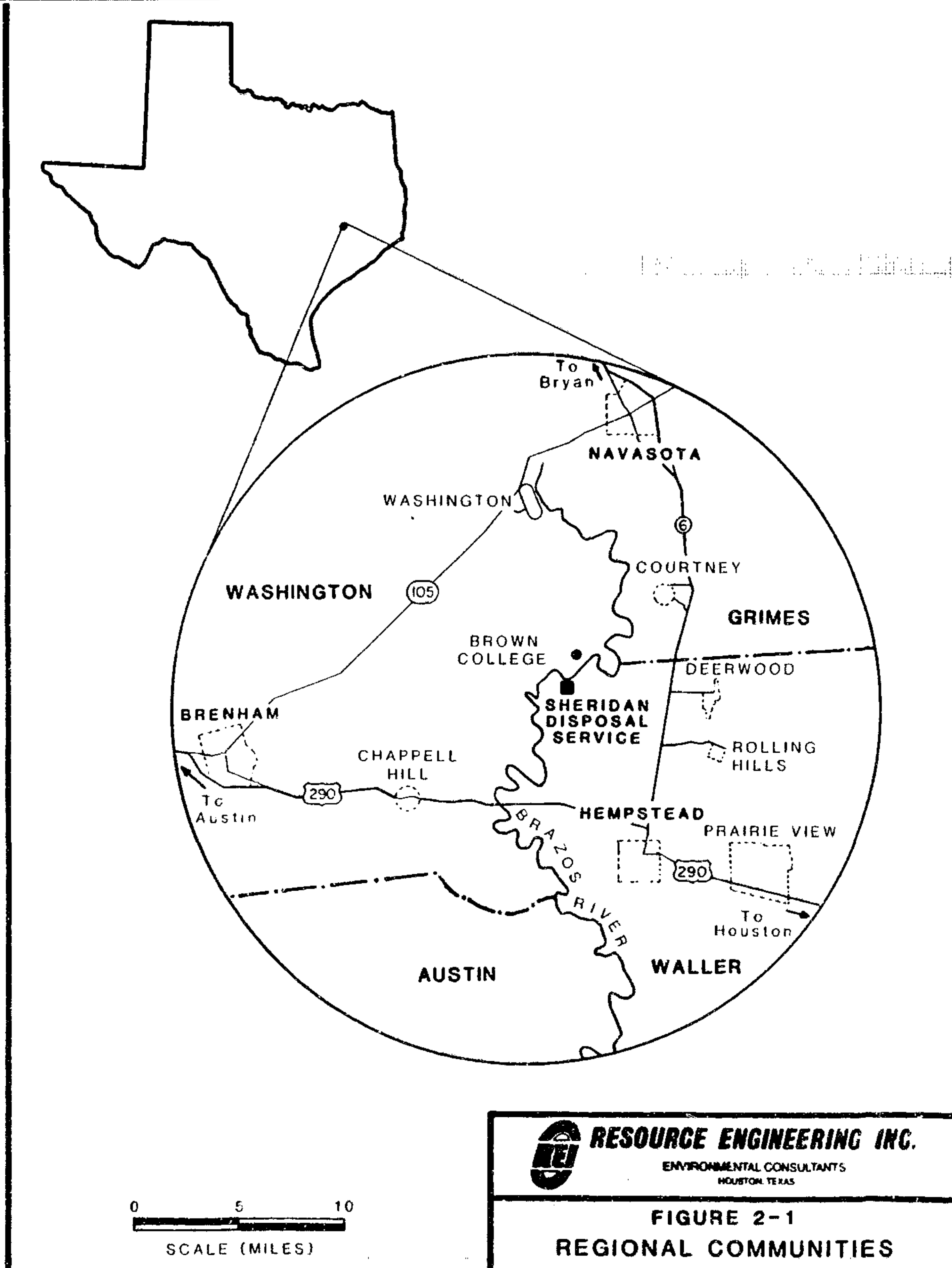

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FIGURE 2-1
REGIONAL COMMUNITIES
SHERIDAN DISPOSAL SERVICE

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L.M.G.	3-3-86	288-04

- ingestion;
- skin contact; and
- inhalation.

Of the three potential exposure pathways, only ingestion could be of public health significance. Skin contact with contaminated materials is limited to the site and is, therefore, not a public health concern. Inhalation of contaminants is not a public health concern. Air monitoring results show contamination levels of hazardous substance compounds are not above background levels during average annual ambient conditions. The potential for contaminant ingestion can be further subdivided into the categories of groundwater, surface water, and food chain.

8.2.1 <u>Groundwater</u> - Groundwater is the major source of water for municipal, industrial, domestic, and irrigation use in Waller County. Those water wells within a three-mile radius of the site have been identified and located on Table 4-1 and Figure 4-1, respectively. The majority of these wells are identified for domestic use.

Groundwater quality will be discussed in the Groundwater Migration Management RI Report.

8.2.2 <u>Surface Water</u> - The northern boundary of the Sheridan property borders the Brazos River at an approximate elevation of 172 feet MSL. The land surface slopes away from the river. Generally, the stormwater flow travels south and then west to the main drainage ditch leading to Donahoe Creek. Donahoe Creek ultimately discharges into the Brazos River approximately one mile southwest of the Sheridan property.

The man-made Clark Lake is located across the central portion of the Sheridan property and within the normal stormwater drainage flow. The nearby diked evaporation system does not discharge any water to Clark Lake.

Resource Engineering also tested the water in Clark Lake for priority pollutants during an aquatic biology survey in September, 1984. No priority pollutant organic compounds were detected in the lake water.

The Texas Water Commission (TWC) has classified the segment of the Brazos River bordering the Sheridan property as effluent limited. Its uses include contact and non-contact recreation, propagation of fish and wildlife, irrigation, and domestic raw water supply. The closest downstream surface water permit for drinking water, according to the Brazos River Authority, is located in Freeport, Texas approximately 120 river miles from the SDS site.

Since the shallow aquifer is in hydraulic connection with the Brazos River, upstream and downstream water samples were collected and analyzed for priority pollutants on April 26, 1984. The results of this sampling indicate that the discharge of the shallow aquifer to the Brazos has not impacted the water quality of the river.

8.2.3 Food Chain Contamination - The land use of the area directly surrounding the SDS site is agricultural, including pasture and rangeland. Approximately 50 to 60 cattle graze on the land around the site.

In January, 1986, a cattle biological sampling program was undertaken on a representative cross-section of the herd with respect to age and sex. The tests involved taking tissue sample from the cattle to assess the bioaccumulation of any significant levels of or PCBs are blood sampling for lead.

The samples were sent to the Texas Veterinary Medical Diagnostic Laboratory for analysis. No lead was detected in the cattle blood. The fat samples were scanned by a gas chromatograph (GC) for PCBs. No PCBs were detected in the cattle in the fat tissues. The GC scan did incidentally detect minute quantities of DDE in four samples which were all less than 0.5 ppm. DDE is a metabolite of DDT. It is suspected that DDT was introduced through historic agricultural use at this site. The USDA acceptable residue of DDT and metabolites in cattle fat is 5 ppm. Table 1 summarizes all analytical results. The DDE results are further defined in Table 2.

8.3 Environmental Impact

8.3.1 Surface Water - It was previously concluded that the quality of the Brazos River water is not impacted by the SDS site. The TDWR sampled the river for damage to aquatic

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life both on March 9, 1972 and May 19, 1977. Samples were collected from three stations that were located 3 miles upstream, 100 meters downstream, and 1 mile downstream of the site. This study concluded that there was no noticeable impact on the aquatic life of the Brazos River due to the SDS site.

A 100-year flood event would inundate the evaporative system. The environmental impacts of potentially contaminated stormwater runoff would be expected to be minimal considering dilution effects.

8.3.2 Flora and Fauna - The diversity of plant and animal life as well as ecological habitats at and ajoining the SDS site is high. Over 90 woody and herbaceous vascular plants were recorded. Some 73 species of birds and 12 species of mammals were also identified.

The pond has evidence of abundant floral and fauna species, down to the water's edge. As discussed in Chapter 7 and Appendices 7A and 7B, the pond does not appear to contribute any stress to the environment. The pond would only present a threat to the animal community through direct contact. Birds who land in the pond could be injured or killed by the patches of floating oil.

The water quality of Clark Lake was under investigation by the TDWR in March, 1978 after a fish kill in the lake. The investigation determined that the probable cause was anaerobic conditions resulting from an overflow of

Table 8-1

Cattle Blood Sampling Analytical Results

(REI Data January, 1986)

Sample Animal	Blood Lead (ppm)	Fat PCBs (ppm)	DDE (ppm)
CA1	<0.2	-	-
*CA2	<0.2	ND,ND(<0.1)	0.27, 0.24
CA3	<0.2	ND(<0.1)	ND(<0.1)
CA4	<0.2	ND(<0.1)	ND(<0.1)
CA5	<0.2	ND(<0.1)	ND(<0.1)
CA6	<0.2	ND(<0.1)	0.28
CA7	<0.2	ND(<0.1)	ND(<0.1)
CA8	<0.2	ND(<0.1)	ND(<0.1)
CA9	<0.2	ND(<0.1)	ND(<0.1)
CA10	<0.2	ND(<0.1)	0.37
CA11	<0.2	ND(<0.1)	0.55
CA12	<0.2	-	-
CA13	<0.2	ND(<0.1)	ND(<0.1)
Blank Fat Tissue		ND(<0.1)	ND(<0.1)

* Replicate fat tissue samples were analyzed for CA2.

ND - Not detected

- Not Analyzed

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Table 8-2

Summary of DDE Residue Levels

in Cattle Fat Tissue

(REI Data January 1986)

Cattle	DDE (ppm)	USDA Acceptable DDE Levels (ppm)
Bull 2 yr.	.27	5
duplicate	.24	
Calf 6 mo.	.28	5
Calf 6 mo.	.37	5
Cow 2 yr.	.55	5

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wastewater from the evaporation system. In September, 1984 an aquatic biology survey was conducted on Clark Lake by Resource Engineering. The results of the survey were submitted to the EPA in October, 1984 in a report entitled "Aquatic Survey of Clark Lake at Sheridan Disposal Service."

The lake supports benthic, nektonic, and amphibious species which suggests a balanced, aquatic ecosystem. Grass shrimp is a species which is sensitive to the presence of organic contamination. A number of these shrimp was collected during the 1984 survey. The presence of mature grass shrimp indicates that the lake does not have any toxic organic contamination from the SDS site. Dissolved oxygen measurements were also taken at that time from 10 sample locations around the lake. All measurements were above the minimum level of D.O. necessary to support a diverse ecosystem (i.e., 2.0 mg/1).

8.3.3 <u>Conclusions</u>

- SDS oral toxicity tests suggests the sludges are at worst only slightly toxic based on LD50 studies effects. Chronic and potential carcinogenic long-term effects will be discussed in the Endangerment Assessment.

- Air monitoring has shown no concentrations of RCRA Hazardous Substance List organic compounds above normal background levels at average annual ambient conditions.

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- No permanent residences are located within one mile from the site; a very low population density exists in the general area. However, a site caretaker resides 2000 ft southeast of the pond in a mobile home.

- There is no direct discharge of contaminated surface water from this site under average ambient site weather conditions.

- Brazos River water analysis has shown no contamination attributable to the SDS site.

- Cattle tissue and blood analysis suggests no contaminants from this site in the food chain.

- A diversity of plant and animal life are present at the site.

- A detailed analysis of Clark Lake shows a normal, thriving, aquatic ecosystem (Appendix 7C).

TDWR and its predecessor agency's interactions included the approval for disposal of additional waste streams, site inspections, and design assistance in the development of the evaporation system

9.1.1 <u>Near Future Impacts</u> - A recent ecological survey of the site indicated no existing detrimental effects on the flora and fauna from the presence of hazardous constituents at the site. The only exception could be to water fowl from direct contact with floating oils on the pond (Chapter 7.0).

A Groundwater Migration Management Remedial Investigation Report will address the potential impacts on local drinking water supplies, the water table aquifer and the first confined aquifer (Chapter 4.0).

Preliminary evaluations of recent air investigations by the EPA's Emergency Response Team and Resource Engineering indicate that the site does not significantly impact local air quality (Chapter 6.0). This will be further evaluated in the Endangerment Assessment. Also, the feasibility study will address the impacts of disturbing the sludge during interim response actions.

If left unmanaged, the most significant near future impact is the potential for overflow of contaminated stormwater from the pond into Clark Lake and the Brazos River. As discussed in Chapter 5.0, stormwater accumulation could result in dike overtopping within 3 to 5 years, if not managed. Releases could impact local aquatic habitats.

9.0 SUMMARY OF INVESTIGATIONS

9.1 Site Background - The Sheridan Disposal Services (SDS) site is located approximately 9 miles north-northwest of Hempstead, in Waller County, Texas. SDS began operations as an industrial waste disposal facility in the late 1950s.

At present, the site includes a 42-acre land irrigation/evaporation system, and a pond and levee with a total surface area of 30 acres. The pond has a water surface area that has ranged from 12 to 22 acres depending on the water level. The levee/dike around the pond has a surface area of approximately 17 acres including portions of the pond which have previously been closed. An incinerator/evaporator and a battery of 9 storage tanks are located on the pond levee. The tanks were used for separation and treatment of oil/water emulsions and storage of solvents and fuel oils.

The facility's waste management operations included open pit burning, incineration, surface impoundment disposal, and land irrigation/evaporation of pond stormwaters.

The site's regulatory history dates back to March of 1963 when a waste disposal permit was received from the Texas Water Pollution Control Board. In May of 1975, Sheridan Disposal Services received an operating permit for a liquid waste burner system. The extensive regulatory agency interaction with waste management operations at the site is documented in the site timeline, Table 1-1, in Chapter 1.

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9.1.2 Site Investigation Summary - Site investigations were conducted by the State of Texas regulatory agencies. These investigations consisted of inspections and sample collection. The scope of these investigations increased in the later years of site operation and closure. In July of 1983, an EPA field investigation team conducted a site survey to collect background data for evaluating the site's eligibility for the National Priorities List under CERCLA.

Resource Engineering Inc. was retained in February of 1984 by the Sheridan Site Committee to provide technical assistance in developing a site closure plan. A series of technical reports was submitted to the Texas Department of Water Resources and Region VI of the Environmental Protection Agency. This Remedial Investigation report reviews all data obtained from the various field investigations.

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9.2 Site Features Investigations

9.2.1 Demography - The major communities in the vicinity of the SDS site are Hempstead and Prairie View, located in Waller County, and Washington and Chappell Hill, located in Washington County. The 1985 estimated population for the area within 12 miles of the SDS site is 15,527, which amounts to an average of 35 people or 12 households per square mile. This is an increase of 23 percent from the 1980 census.

Over 60% of the residents within the area studied reside within the major towns and communities described, with sparse residences in the largely rural areas closest to the SDS site.

9.2.2 Land Use - Land use within a four-mile radius of the SDS site is mostly agricultural--rangeland for pasture, growing of livestock feed, and various truck farm crops. Land not used for agriculture is left as woodlands.

The only land devoted to residential use within this four-mile radius of the site is the Brown College community. The remainder of the area is only sparsely populated.

9.2.3 Area Resources - The resources of importance in the area surrounding the SDS site are surface water, groundwater, soil, natural gas, sand and gravel. The largest and most prominent body of surface water is the Brazos River, which borders the SDS site on the north. There are several creeks, small lakes, ponds, and oxbow lakes within a four-mile radius.

The water needs of Waller and Washington Counties are supplied by groundwater coming from the Jasper and Evangeline aquifers. The Burkeville aquiclude and Brazos River alluvium are also used for limited amounts of water.

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Natural gas and gravel are present in minor amounts. Close to the SDS site are two natural gas wells; a gravel pit is located four miles to the east. At least two additional natural gas wells are currently being completed within a two-mile radius of the site.

9.2.4 Climatology - The climatology of the area is generally maritime with cool winters and hot summers. Precipitation is uniform throughout the year with annual rainfall averaging 40 inches per year. Humidity is relatively high, ranging from 60 to 90 percent. On average, evaporation in the area exceeds precipitation by 15 inches per year. Evaporation exceeds precipitation in March through November. 003716

9.3 Hazardous Substances Investigation - Sheridan Disposal Services accepted a wide range of wastes from a broad cross-section of Gulf Coast industries. A survey of available records indicates 217 generators contributed waste to the site; wastes were shipped by 43 different transporters. It is estimated that the total amount of wastes received by the SDS site exceeded 85 million gallons. The major waste management areas are the:

- disposal pond,
- disposal pond levees, and
- evaporation system.

9.3.1 <u>Disposal Pond</u> - The disposal pond was the original waste management area at the SDS site. The original waste disposal practice at the site involved open burning of wastes and disposal of any ash residue in a small farm pond located in a natural depression at the Sheridan property. As the volume of wastes increased, surrounding soils and combustion ash were used to construct a dike around the disposal pond. The pond water surface area has ranged from 12 to 22 acres depending on the water level. Approximately 5 acres of the pond in the north and 2 acres in the southeast section have been filled with construction debris and dike material. This was done as part of initial closure activities by SDS during 1979-1984.

The pond contains from 85,000 to 105,000 cubic yards of organic sludges which contain approximately 50% by weight water and volatile organics; 30% nonvolatile organics; and 20% inorganic materials (Table 3-4). This includes sludge which has seeped into or been covered by the pond levee. The pond sludge varies in depth from 4" to 3'6" while sludge in the levee varies from 4' to 6' based on borings. Assuming 3 feet of contaminant migration into the subsoils, there is a potential for an additional 60,00 cubic yards of contaminated subsoils beneath the sludge. While the calculations were based on an estimated contaminant mic .tion of three feet, it is possible that the extent of migration could be greater or less

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than three feet. The extent of soil contamination will be further defined in the Supplemental Soil Investigation.

The pond sludge contains a wide variety of inorganic salts and metallic compounds which could affect the choice of remediation (Tables 3-2, 3-3). The major priority pollutant organic compounds detected were (Tables 3-5, 3-6):

- volatile aromatics - toluene, ethylbenzene, and benzene;
- volatile chlorinated solvents - tetrachloroethylene, 1,1,1 trichloroethane, and trichoroethylene;
- phenols - phenol; 2,4-dimethyl phenol;
- polynuclear aromatic hydrocarbons - isophorone, naphthalene, fluorene, phenanthrene and anthracene; and
- polychlorinated biphenyls - isomers Aroclor 1242 and Aroclor 1260.

Other organic compounds detected included C_3 and C_2 alkyl-phenols, aromatic hydrocarbons, biphenyl, aromatic ketones, alkyl benzenes and aromatic ethers.

Volatile aromatics represent approximately 5% by weight of the pond sludge composition. Toluene is the major volatile organic with a concentration determination to be up to 36,600 mg/kg. Polychlorinated biphenyls (PCBs) are present as

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Aroclor 1242 and Aroclor 1260 and range in concentration from 0 to 223 mg/kg in the disposal pond sludge.

9.3.2 Disposal Pond Levee - The levee or dike around the pond has a surface area of approximately 17 acres. The levee was constructed from surrounding clay topsoils and solid wastes from on-site treatment operations. The solid wastes consisted of diatomaceous earth ash residues from on-site incineration and open pit burning operations. The elevation at the top of the levee varies from approximately 176.5 to 185 feet above mean sea level.

The treatment processes at the SDS site are all located on the top of the levee. The treatment units included a receiving pond, an incinerator/evaporator, a boiler, and a battery of 9 storage tanks. The storage tanks were used for separation and treatment of oil/water emulsions and storage of solvents and fuel oils. According to an as-built site plan prepared by O'Malley and Clay Inc. in 1972 for SDS, the tanks vary in size from 500 to 1000 barrels. The tanks contain from 3 to 7 cubic yards each of bottom sludges, which appear to have characteristics similar to the pond sludge based on observations of the tank sludges and discussions with Mr. Sheridan. A composite sample will be tested during preparation of the feasibility study.

The levee system has a volume of approximately 165,000 cubic yards. Additional field investigations are planned to characterize the extent of contamination in the levee system. Cone penetrometer soundings and borings in the levee indicate that the heavy sludge layer extends into approximately 30% of the levee system and is up to 4 to 6 feet thick in sections. Historical records show that steel drums were placed within the north and west sections of the pond levee. Empty drums are visible in the levee material throughout the north and west sections.

A slope stability analysis of the levee is presented in Appendix 5D; it indicates adequate safety factors exist for the current structure.

9.3.3 <u>Evaporation System</u> - The evaporation system is a 42-acre system of impoundment cells conceived as an "evaporation/rapid infiltration method of flood irrigation" for treatment of pond wastewaters. From 1976 through 1984, more than 40 million gallons of lagoon wastewater were treated in the evaporation system based on TDWR records.

The primary priority pollutants in the pond wastewater were determined in a June, 1984 analysis by GC/MS to be:

- phenol (3.55 mg/l),
- trichloroethylene (2.910 mg/l),
- toluene (1.61 mg/l), and
- tetrachloroethylene (0.51 mg/l).

Analyses by the TDWR and Resource Engineering indicate the organic compounds and heavy metals of the pond wastewater generally decreased in concentration with progression through the evaporation system cells (Table 3-11). Phenol and toluene are readily biodegraded (Table 3-24) and toluene, trichloroethylene and ethylbenzene are highly volatile from soils (Tables 3-20, 3-22, 3-23). To date priority pollutant organics found in the evaporation system were only in areas of surface sludge contamination, and included: phenol, ethylbenzene, toluene, benzene, 2-4-dimethyphenol, tetrachloroethylene, and N-nitrosodiphenylamine. Additional sampling of the evaporative system is planned as part of the Supplemental Soil Investigations.

Table 3-19 compares heavy metal concentration ranges found in the evaporation system to site background; common background ranges found in US soils; excessive phytotoxic levels; and EPA maximum metal concentrations for in place closure of hazardous waste land treatment units. The upper limit of heavy metal values were all from a worst case sludge sample located in the inlet cell of the evaporation system. The inlet cell of the evaporation system was an anomaly since the maximum metal concentrations found in the other cells were:

Table 3-19

Heavy Metal Remedial Concentration Levels

(mg/kg)

	Evaporation System Range	Preliminary Site Background	Common Background Range[1]	Phytotoxic Levels[2]	EPA Maximum Metal Concentrations For In-Place Closure of Hazardous Waste Land Treatment Unit[1]
Chromium	<1.4 - 204	12.1 ± 19.9	1 - 1,000	75 - 100	1,000
Lead	5 - 691	7.3 ± 18.5	2 - 200	100 - 400	1,000
Nickel	<1.4 - 44	15.7 ± 24.5	5 - 500	100	100
Zinc	22 - 1260	30.8 ± 44.6	10 - 300	70 - 400	500

1 Source: USEPA, Office of Solid Waste and Emergency Response, Hazardous Waste Land Treatment, SW-874, April 1983

2 Source: Pendias, A.K, and Pendias S.H. 1984. Trace Elements in Soils and Plants, CRC Press.

Chromium	56 mg/kg
Lead	188 mg/kg
Nickel	44 mg/kg
Zinc	145 mg/kg

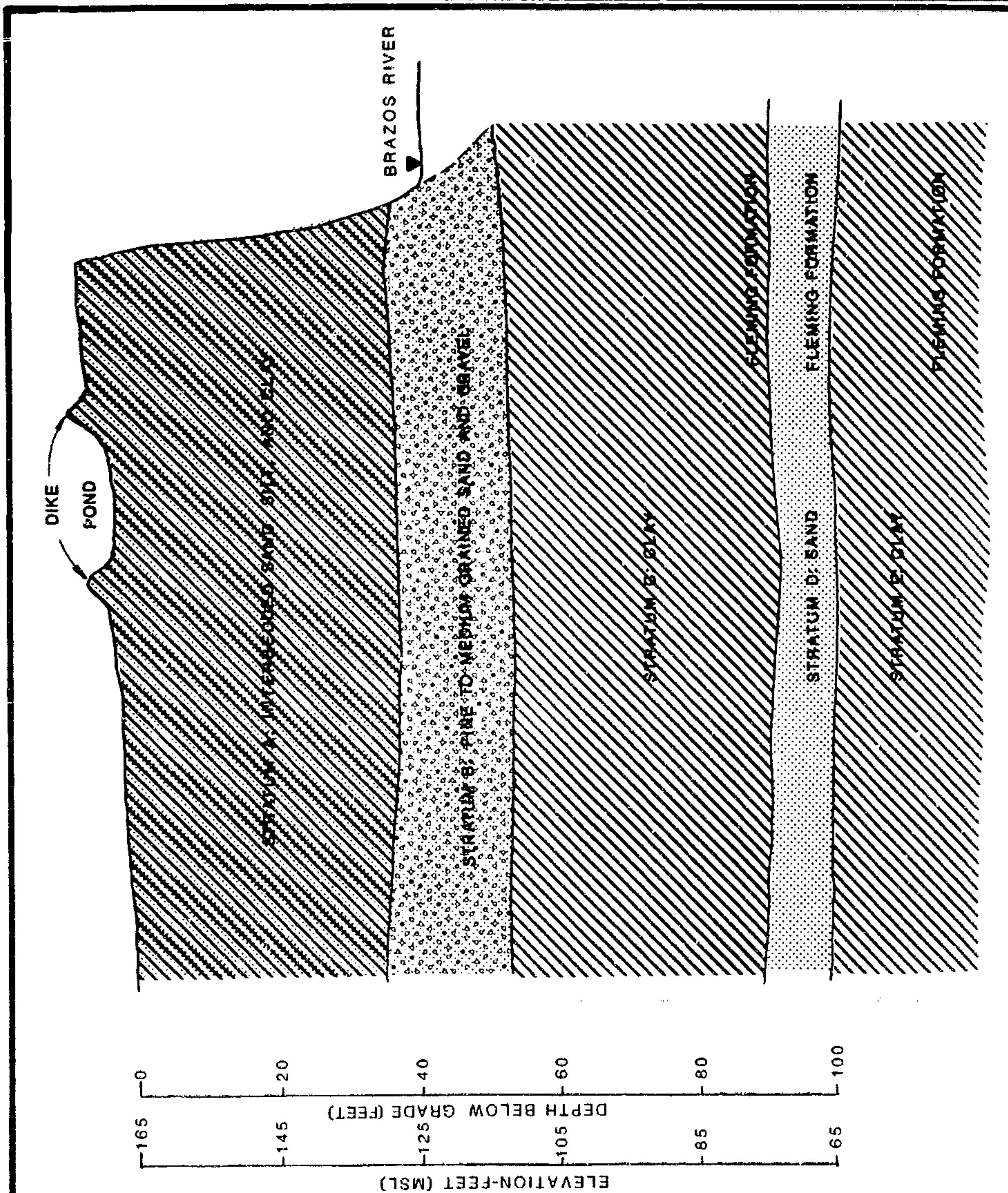
Additional soil sampling is planned to further characterize the evaporation system.

Overall soil conditions at the site do not favor the mobility of heavy metals. Because of the clay thickness in aquitard layers, heavy metal migration to groundwater is not likely. This will be further addressed in the Groundwater Migration Management R.I.

9.4 Hydrogeologic Regime and Soils

9.4.1 Geology - The SDS site is located in the Brazos River drainage basin. The basin is a fluvial system which consists of interbedded sand, silt, and clay. There are seven sedimentary units in the area. They are, from oldest to youngest: Fleming Formation, Goliad Sand, Willis Sand, Bentley Formation, Montgomery Formation, Beaumont Clay, and recent alluvium of the Brazos River.

The entire SDS site is located on the floodplain alluvium of the Brazos River. The stratigraphy of the site is typical of alluvial deposits, consisting of sands, silts and clay. These are interbedded and graded laterally and vertically into finer and coarser material.



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RESOURCE ENGINEERING INC.
ENVIRONMENTAL CONSULTANTS
HOUSTON, TEXAS

FIGURE 4-4

GENERAL SCHEMATIC SITE GEOLOGY

SHERIDAN DISPOSAL SERVICE

DRAWN BY:	DATE:	PROJECT NO.
L.C.S.	2/20/88	288-04

In general, there are five strata at the site designated A, B, C, D, and E. These strata are shown in Chapter 4, Figure 4-4. Stratum A, the upper 40 feet, consists of interbedded sand, silt and clay. The eastern part of the site is situated on a silty clay approximately 30 feet thick. This silty clay pinches out and grades into a silty sand towards the west. The silty sand covers the western part of the site and ranges in thickness from 20 to 40 feet.

Stratum B is a fine- to medium-grained sand that contains thin silt and clay seams. This layer is approximately 40 feet below grade and an average of 15 feet thick. Gravel is interbedded within the sand in the lower part of the sequence.

Stratum C is a dense clay layer that is approximately 55 feet below grade, and averages 25 feet thick. The clay becomes somewhat sandier with depth.

Stratum D is fine- to medium-grained sand is approximately 90 feet below grade. The sand averages 10 to 12 feet thick. Stratum D is confined by Stratum C.

Stratum E is a dense clay layer approximately 100 feet below grade. This layer is the deepest geologic unit investigated at the site.

9.4.2 <u>Site Hydrology</u> - There are two aquifers present within the upper 100 feet at the SDS site--a water table aquifer (Stratum A and B) and a confined aquifer (Stratum D). The water table aquifer is the first aquifer encountered below grade. It consists of the upper 55 feet of sands, silts, and clay. The confined aquifer is 80 feet below grade and is separated from the water table aquifer by a 25 to 30-foot thick clay stratum (Stratum C).

Seventeen monitor wells were installed in the water table aquifer during the past 14 years by various state regulatory agencies and consultants. One pump test well and four piezometers were recently installed to determine the hydrologic characteristics of the water table aquifer.

The transmissivity and permeability of the water table aquifer were found to be 4.0×10^3 gpd/ft and 7.9×10^{-3} cm/sec, respectively.

The permeability values are within the range of published values for a silty sand. Because of this relatively low permeability, however, the water table aquifer would be marginal as a source for domestic water use.

Groundwater flow in the water table aquifer at the site is generally northwest towards and into the Brazos River. However, the direction of groundwater flow is dependent upon the stage of the river.

During high river stage, the groundwater will temporarily flow from the river into the alluvium. Also under these conditions the direction of the groundwater is to the west. These conditions are temporary; when the river stage returns to normal, groundwater will again discharge into the river.

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Groundwater velocities in the water table vary during the year. Velocities range from 57 to 157 ft/yr, based on recent water level measurement.

Underlying the water table aquifer is the confined aquifer. A pump test was conducted on this stratum using a pump test well and four piezometers to determine the aquifer's hydrologic characteristics. The transmissivity, permeability and storage coefficient are 1.4 x 10^3 gpd/ft, 5.8 x 10^{-3} cm/sec and 7.6 x 10^{-4}, respectively.

The permeability value is within the range of published permeabilities for a fine- to medium-grained sand. The aquifer could sustain a domestic water well, but may not sustain a low producing irrigation well. It could not sustain a municipal production well.

Groundwater flow in the confined aquifer is mostly westerly. During periods of low stage in the river, groundwater flow in the confined aquifer is towards the river and its piezometric potential is greater than the elevation of the water table aquifer. However, during high river stage, the groundwater flow direction is westerly. The groundwater elevation of the water table aquifer is then higher than the piezometric potential of the confined aquifer.

Groundwater velocities of the confined aquifer are relatively slow, three to seven ft/yr. This is because of the relatively level piezometric potential surface of the aquifer.

There is the potential for a hydraulic connection between the water table aquifer (Stratum B) and the first confined aquifer (Stratum D) at the SDS site. However, the realization of this connection is unlikely in view of the predominantly upward gradient from the confined aquifer.

9.4.3 Water Quality - Groundwater quality will be discussed in the Supplemental Hydrogeologic RI report.

9.4.4 Soils - The SDS site is located on soils of the Brazoria-Norwood Association. This association consists of soils on broad floodplains along the Brazos River. The surface soils are level to gently sloping, somewhat poorly drained to well drained, and clayey to loamy. These soils are considered to have high potential for crop and pasture production.

9.5 Surface Water Investigations

9.5.1 Brazos River - The Brazos River is the dominant water feature in the area. The Brazos River borders the SDS site to the north and is less than 200 feet from the pond. The Brazos River flow is highly variable and ranges from 137 to 143,000 cubic feet per second depending upon local and upstream rainfall.

River water sampling indicates the site has no current impact on surface water quality of the Brazos River (Table 5-2).

9.5.2 Clark Lake - Clark Lake is a series of three shallow ponds formed by two man-made, earthen dams in a natural drainage channel. The pond system impounds approximately 60 acre-ft of water and is located south of the disposal pond and the evaporation system at the SDS (Figure 5-3).

A fish kill occurred in Clark Lake during March, 1978. Investigations by the Texas Department of Water Resources determined that the probable cause was anaerobic conditions caused by an overflow of wastewater from a damaged cell in the evaporation system.

An aquatic biota survey of the Clark Lake system conducted by Resource Engineering, Inc. in September, 1984 indicated an active and diverse aquatic ecosystem. Sediment samples of Clark Lake were obtained by Resource Engineering, Inc. and analyzed by GC/MS for priority pollutants (Table 5-2). No adverse impacts from the 1978 spill remain.

9.5.3 Surface Hydrology - The 100-year floodplain level is 175 feet above mean sea level, according to a recent Corps of Engineers study (Appendix 5B). The pond levee is 176.5 feet above MSL at its lowest point and, therefore, able to withstand a 100-year flood event. Stormwater runoff calculations for the site are presented in Section 5.3.3 and illustrated in Figure 5.5.

The 100 year flood event would inundate the evaporative system. The environmental impacts of the potentially contaminated stormwater runoff would be expected to be minimal considering dilution effects.

If left unmanaged, the pond will accumulate stormwater at an approximate rate of 6.8 million gallons per year. Based on this datum and pond dimensions from an aerial survey of the site (Figure 5-5), the pond can be expected to store all precipitation falling within the dikes for 3 to 5 years from the date of this survey (July, 1984) if no interim stormwater management actions are taken.

9.6 Air Investigations - The following conclusions can be made of ambient air quality at the Sheridan Disposal site based on independent sampling and analysis by Resource Engineering, Inc. and the EPA's Emergency Response Team in March, 1986:

- The site has no detectable volatile emissions of polychlorinated biphenyls (PCBs) based on detection limits of 0.003 mg/m^3 at average annual, ambient weather conditions.
- The site has no detectable emissions of volatile RCRA Hazardous Substance List organic compounds above background levels or listed RCRA hazardous substances during average annual ambient weather conditions.

9.7 Biota Investigations - An extensive ecological survey of the Sheridan Disposal Services (SDS) site was conducted in January, February, and June 1986. The conclusions of the survey were:

- No stress on the surrounding plant and animal communities was attributable to the materials in the diked disposal pond. An abundance of floral and faunal species occurs on the dike, even down to the edge of the water. No differences in plant growth were found in the direction of the flow of shallow groundwater toward the Brazos River nor in any other direction. There is no runoff toward Clark Lake from the disposal pond (Figure 7-5).

- Diversity of ecological habitats at the site is high, with an attendant diversity of plant species. Diversity of animal species is correspondingly high with total numbers as large or larger than would be expected.

- Birds are particularly abundant, both with regard to species and to individual numbers.

- Construction of a diked evaporation field created a new habitat for wildlife on the SDS site--one that did not previously exist. Shore birds and water fowl flock to the evaporative system to feed on organisms breeding in the shallow water and wet mud. See Appendix 7A, 7.1.2.

- Clark Lake on the Sheridan tract and an oxbow pond on the adjacent Styers property appear to have thriving populations of aquatic plants and animals. Fish, turtles, frogs and insects were seen in abundance. A number of birds and mammals feed on these organisms.

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- Forest trees adjacent to the disposal pit and evaporation field appear to be in good health. Nearby pecans and southern red oaks are very large and are producing good crops of nuts and acorns. Large cedar elms are extremely productive.

- No deleterious effects on wildlife can be attributed to oils or chemicals spreading from the disposal area. A seeming scarcity of small rodents and terrestrial reptiles almost certainly stems from a lack of suitable ground cover due to heavy grazing of cattle.

- The only immediate threat to animal life from the disposal pond is one of physical contact by water fowl. Birds landing on the pond may be injured or killed by contact with floating oil.

- No federal or state-listed endangered plant or animal species were detected on the site. One bird, the bald eagle, could conceivably wander through in winter, but no evidence of nesting was found.

9.8 Public Health and Environmental Concern - Excluding groundwater, of the potential pathways of exposure to hazardous constituents from SDS--surface water, air and direct contact--only direct contact appears to present a potential risk under current site conditions. This will be subject to further evaluation in the Endangerment Assessment.